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CORE-MAKING AND CORE MACHINES.

By Archie M. Loudon, Elmira, N. Y.

Ever since the earliest days of founding metals, it has been as necessary to make cores as it was to make the molds themselves for turning out the shapes desired. As the subject in hand is the making of cores for castings, I will treat it independent of all other items that enter into the making of the latter.

Cores are made principally from sands in various mixtures, and in containers of the proper materials and shapes as these may be required. We will discuss more particularly small and complicated cores, both hand made and machine made. Up to within recent times, these have always been made by hand by the foundryman, and this has made the castings in question very expensive.

Of late years we have had the benefit of several ingenious machines enabling us to produce cores at a fraction of the cost of hand made ones of the same character. My first recollection was of a foot power jarring machine to make round, square, and oval cores—when straight; making as many as a dozen at one operation. The operator was enabled to rod and vent after ramming with one operation to each part—to rod and then vent the whole dozen cores with one movement. The outfit was simple and cheap.

Several other devices of like nature came into use, but seem to have passed into oblivion. With the introduction of the worm machine—extensively advertised and generally used—in several forms but differing little in principle, all the cores that can be made with them are produced very cheap indeed. Later on we have the small hand ramming roll-over core machines, which have been extensively exploited on the basis of their particular merits in producing cores of different shapes and character. Also we may mention the small jarring roll-over core machines of different types, which simplify the production and greatly lower the cost.

The latest development, to my knowledge, is a power ramming roll-over core machine of a greater capacity than any here-

tofore brought out. This machine is practically an automatic core-maker, turning out work of almost any size and shape, up to 18 in. width and 32 in. length, by 12 in. depth, with the option of using smaller cores by duplicate boxes at one operation. The cost of making cores with this machine is anywhere from one-fifth to one-tenth that of making these cores by hand. It is not necessary to mount special core boxes for this machine, as those in daily use in a foundry, supplied with two battens for the clamping device, will answer perfectly. With this machine there is supplied a device for pasting and venting cores which enhances the quality of the work, and cheapens it wonderfully.

Cores are made by a number of methods, when produced by hand from core boxes. In the case of cores made in halves and then pasted, the following would take place. The core-maker takes the box, fills it with his core sand mixture and begins to ram it. When rammed up hard enough, using a rod or rammer for this purpose, he puts rods into the core, if he has not done this while ramming up, the sand first put into the box. He then again fills up the box and rams as before. Then he butts all over sufficiently high enough to allow scraping off with an iron or wooden straight-edge, so that he will leave a level joint for matching the two halves when pasting. After scraping off, he cuts a gutter for the vent, and then uses the vent wire in cases where the cores are large enough to require this. This operation pricks the box and ultimately destroys it.

The above being the usual method employed, I wish to call your attention to the fact that when the core-maker rams a core he does so only on the spot immediately at the surface of the rammer, and at the same time displacing the sand in all the other parts near-by. This results in his ramming over and over again at the same place, turning out a core unevenly rammed, hard and soft in spots, causing more blown and scabbed castings—where the core was at fault, than from any other cause.

In making oil-sand cores by hand, in order to secure good substantial cores for molds, it is necessary in some foundries to rod up to such an extent that the cost of removing the wires and rods used is oftentimes greater than the cost of making the cores themselves. This is a fact which foundrymen will readily appreciate.

Differences in cores made by several men from the same mixture, and which are often the cause of trouble, argument, and the ultimate discharge of an otherwise good man, may be traced to lack of knowledge on the part of the operative, who oftentimes has no one to tell him any better. This is not intended as a reflection on the man in authority, nor a defense of the incompetent core-maker, but simply to bring out the fact that the core rooms in most of our foundries have been so long left to chance for results, that I feel safe in saying that most of us need to learn more about core-making than we know, and if given to self-examination would promptly admit it.

As I have written on this subject in the past, and have emphasized the improper mixture of sands and binders as the great core-room evil, I may freely state now, judging from the experience of other foundrymen as well as from my own, that this is after all not so serious as it seems. With homogeneous material—that is properly and evenly rammed—with the necessary amount of rodding, and no more, there are a hundred and one mixtures which will produce the desired results, but only when done that way. Attention given to even ramming will develop a better quality in the core as well as cheapen it. With all the existing troubles the foundry business has to contend with so that a small margin of profit may remain, this is important.

Foundrymen are therefore urged to give their attention to the study of machines for making cores in which even ramming and homogeneity of material is attained, for therein lies a source of economy in their shops.

American Foundrymen's Association

A VIEW OF THE FOUNDRY AT CLOSE RANGE.

By Benj. D. Fuller, Cleveland, O.

We who follow the Foundry Industry as a means of livelihood must ever be thankful for the existence of the American Foundrymen's Association, as it has undoubtedly been a great source of useful information and education, and has accomplished much towards foundry advancement. We are accustomed to listen to learned technical discussions, and do not question their worth. But there are many among us understanding talk about Air, Blast, Coke, Fireclay, etc., who are more or less lost when discussion of the same subject is couched in such terms as "Carbon-dioxides, Monoxides, Calcium, Alumina, etc." For such as these a talk on the every-day common-place subjects connected with the shop may not be considered out of place. Men (and I am one such) whose pleasure it is to religiously visit the cleaning-room bright and early each morning and when seeing a casting with the sand dropping away from it leaving a clean smooth surface, cores falling away with little labor, no fins, scabs, or buckles, a job which speaks of good, mechanical, heady work; feel a thrill of pleasure as of an artist when gazing upon a master-piece, and on the contrary, feel disgust and disappointment upon finding a casting with sand burned on, cores hard, or surface showing scab or swell.

What can the "man behind" do towards being of assistance in accomplishing the desired end, viz., good castings at reasonable cost?

When the problem consists of a shop full of work of a more or less intricate character, with good molders scarce, and a class of men to rely upon the majority of whom are unskilled, there are many things to be considered, not the least of which is the sand.

There is nothing in connection with the foundry more worthy of careful study, and constant watching, than the sand; especially is this so under conditions as above.

I am not going to try to pose as an authority on sand specification by analysis, but where men are working a sand, not suitable through being too close to stand hard ramming with a minimum use of the vent wire, coke bed, or other means of carrying away gases; or the other extreme, a sand too sharp and lacking in bond, contributing towards loss through wash, or drop out, I will guarantee that, given the same men, sand properly mixed and tempered and of a nature to stand ramming, containing bond enough to stand up well in pockets or overhanging projections in the mold or core, and at the same time vent freely, you will find a very marked improvement in quality, as well as decrease in cost of product. Time devoted to ascertaining proportion of new and old sand in facing and core mixture, to seeing that mixing machines are properly operated, that the right proportion of binding material and no more is used, is well spent.

Establish your system and see that it is lived up to, and not changed without a good reason coupled to your consent, and a substantial saving in material plus better product is bound to result.

You may say: "We are mixing core sand 1 to 60." Do you know this to be true? Have you taken pains to work out the proportion and provide means of measuring and mixing, about which there can be no "guess work?"

Again, when large cores are made in quantities the use of cast arbors as a means of safety and economy is generally overlooked. What though it does mean some time daily required from carpenter or patternmaker building and fitting arbor patterns to the boxes. When once you have a stock of arbor patterns it more often means but a slight change to adopt an old pattern to a new job. Suppose it does require one or two men molding these open sand arbors every day. The cast arbor will save days of time in cutting and shaping wrought iron or steel rods, will give a firmer and more stable core, and enable the coremaker to use fine coke or venting material, where he otherwise could not make use of it, which all means that a good core can be produced by a man whom you would not consider the best mechanic. By being enabled to produce good work, such a man soon gains confidence in himself and goes after things in such a manner that before long your painstaking, careful mechanic is left behind

in amount of work produced, for he will not "take a chance," as he is apt to term the breaking away from his "slow but sure" method.

It may, on first sight, look like extravagance to allow rope slings to be used through a shop on core and molding floors where chain or iron beam and sling could be used. But when we figure the gain in time, due to the speed of adjusting a rope which adapts itself to all shapes, I believe, in many cases, it is an actual economy to use them. Also we can see when a rope has outlived its usefulness, as it will give warning, where a chain will snap unexpectedly, often causing accidents which are an everlasting regret.

The practice of drying molds may be carried to an extent which may seem an extravagance at first sight. What I mean is, to walk into a shop and see right and left the burning of charcoal in pans suspended in molds or charcoal in mass upon a sheet of corrugated iron covering a mold. Here again may be an economy, in that men who would require years of careful training to make thorough green sand molders, can in a comparatively short space of time be taught to do good work through dry sand methods. The mold can be rammed harder. It requires less venting, and when wet blacked and slicked, gone over with a final plumbago wash will give surer results, provided the facing sand is right.

Where gas is obtainable this is one of the best agents we have for mold drying, as burners may be formed for jobs which are in day after day, and stunts such as drying drag cheek and cope of the same mold at the same time with the one burner can be carried out, thus saving time, money and space. But for irregular work of odd shape, and work in and out, there is nothing better to my mind than charcoal.

A fireman can be soon taught to suspend and adjust pans in molds, light quickly, and extinguish at the right time. The cost of charcoal over other methods is more than saved in the speed and adaptability with which it can be used.

We most of us, know of the stopper brick used in the bottom of the steel foundry ladle. Brick of this general design with ½-inch wall with hole 1, 1½, 1¾, 2, or 2½ inches in diameter will be found very handy and economical when used in making

pouring gates and runners on heavy work. They are generally made in sections 6 inches long, fitting one into the other, can be laid in the mold in any direction, like laying sewer crock. They will not blow, or swell, and when rammed in cannot burst. The cost is reasonable and the economy in use quite considerable; again, they are one of the means to an end, cutting down the risks and helping the output.

As a further safeguard, the pits in which large castings are made time after time should be carefully arranged to minimize risk, binders across the bottom, heavy cast iron plates on these binders and curbing at least part way up the walls, proper means for adjusting bolts from bottom binders to cope, etc. All these are well-known safeguards, but when applied make the daily work much easier, and save many a casting.

On this class of work a pneumatic rammer in the hands of the molder's helper makes him about as valuable as the molder himself, at least while the ramming is going on, for the outside or back ramming can be done as well by the helper with the air rammer, especially when under the molder's eye.

That indispensable adjunct of the foundry—the pattern-shop—is a veritable gold mine, passed over by many a prospector, "having eyes, yet seeing not," yet here lies hidden a well nigh inexhaustible fund of help worth much time and study. First consider, we must depend upon the pattern-shop fully as much as the foundry for the success of the molding machine, and here let me say, that the molding machine is first of importance on my list of things necessary to success. This is too broad a subject to be covered in this paper, but to emphasize the above statement I will mention the fact that the Westinghouse Electric and Manufacturing Co. have in their iron and brass foundries upwards of six hundred machines in operation.

The more simple the machine, the better the results, as a general statement. I am sometimes lost in trying to figure out what would be the result were we compelled to turn out our foundry product entirely by "old hand" methods, and were this to be put up to me, I would feel like saying "Let George do it," and as yet the field for advancement in this line is great, especially is this true of the large "jar" type for heavy work, with its adjuncts, the grab bucket for handling sand, and the pattern drawing device used independently of the machine.

Construct patterns for the machine direct from the drawings where at all feasible, for not only do we save the cost of original patterns, but save money on every casting "right from the jump." Small castings made by hand from loose patterns cannot be compared as to quality or cost with those made upon machine from proper patterns.

As within the scope of this article, I wish to say something of patterns other than those for the molding machine. Second only to the machine in importance is the match plate system, meaning by this not simply plates with one-half pattern on each side to ram cope and drag upon the same plate, but parts on separate boards, or plates, and as is true of the machine, the more intricate the design, the more they are worth.

In some cases as many as four separate plate patterns for a four-part mold are being used, and there are patterns up to eight feet, and even larger, from which castings are produced which "do your heart good to look upon." Here again, the man not considered the finest mechanic will produce good work. He cannot abuse the pattern by beating it with a hammer, as he cannot reach it. The gates are formed as part of the pattern, thus doing away with a source of much loss, and trouble, for many a job is spoiled in the cutting of the gate.

As a general thing these match plates can be drawn from the mold by means of the simple guide pins in the flask, leaving a perfect mold, but when the draw is too intricate for this method to be successful a simple drawing device can be applied by hand to the match plate after the mold has been rammed, and rolled, which will give a perfect mechanical draw leaving the same as fine as any machine made mold.

Suppose we wish to make a casting of the shape of an oil or molasses barrel, to be cast on end. The usual procedure would be to make the pattern in two parts divided in the center at the greatest circumference, thus necessitating a deep cope, or in case the pattern is large, eight to twelve feet diameter for instance, we would bed in floor, make a slanting part down to center, or dividing line, and use lifting plates. Part again at topmost line, lift plates from center with cope, draw both parts of pattern, replace cope, release bolts to lifting plates, lift cope and finish mold.

Good results can be obtained by this method, but suppose we make the center or core of this pattern, to resemble a section of water pipe, build on the outside in staves, fastening staves by eye bolts through the center pipe, cover upper end of pipe with a lid, ram up simply a two part mold, lift cope, remove lid of pattern, go down inside and unscrew eye bolts, draw out center and pick in the staves—result, a perfect mold, made in much less time, doing away with center parting and much lifting, etc. Can you guess how much this means in a shop where patterns of this style are numerous?

The Cupola, Cleaning Department, Yard Labor, Accounting and Cost Departments, are all subjects calling for time and study, not to be covered in the limits of this article. But I cannot close without a good word for the efficient office man as a valuable assistant. Daily reports are looked upon by many as "red tape." On the contrary, they are of great value in enabling one to locate trouble and to appreciate things of worth. It is a nice thing to be able from reports before you on, say the 15th of the month, to calculate in a minute's time, within a small fraction of a penny per pound what your castings will cost at the finish of the same month. Such records are not difficult to obtain, nor is the system intricate.

Surprises are in store for those who look about them with interest. I have seen results obtained in shops without any modern equipment to speak of which command admiration. I have in mind in the city of Buffalo a shop presided over by an unpretentious man, but a man who knows his shop, and who knows his men.

We often hear it said that "to be a success as a salesman, one must be a mixer," and this is true of the foundryman, he must be a mixer, not in the generally accepted sense of the term, but a mixer who can at the same time command the respect and confidence of those coming under his supervision.

American Foundrymen's Association

MACHINE VERSUS HAND MOLDING.

By John Alexander, Philadelphia, Pa.

In order to keep up with the rapid strides that are being made in the business world these modern times, and to give more confidence to those of us who are contemplating the necessity of producing castings at a much lower cost, combined with a greater output and a better quality of work; it might be well to think of the advancements that have been made in the arts and sciences within the last fifty years. Think of the intricate and simple, as well as ponderous machines that have been invented to facilitate getting out the work in the machine and pattern shops —the two nearest professions to our own, and by turning to any line of business, we readily see that machinery is taking a most wonderful and active part in it, and hand methods are falling behind, everything tending towards specialization and automaticity.

The foundry has been lacking some in this advancement, although in the year 1860 we read and hear of one or two foundrymen using squeezers; then again, four years later, machines for making gear wheels were invented. Again in 1869, the United States Patent Office granted a patent on a jarring machine, but progress after this was slow when compared with machine inventions for other trades, until the year 1894. It seemed as if during the year 1893 (the panic year), that manufacturers in general had time to consider how to push things for a greater production when the busy times would come along again.

As trade improved there was a new impetus given the molding machine, and in 1895 there was a cry all over the country for machine made castings. Then the over-zealous salesmen made a hit in selling machines to the over-anxious foundryman or purchasing agents without either (or some) of them giving thorough consideration to limitations the machine had. From this time on, there was quite an interest taken in molding by machine, until 1905, when conditions demanded a still greater

variety of work from them, and ably met by the molding machine manufacturers. Since that time they with greater experience and confidence kept going ahead, improving and inventing continually all the time. So, in going to conventions, we see for ourselves different demonstrations of almost everything connected with the foundry, and meet and exchange ideas with one another. Through the courtesy of the different foundry proprietors in the cities where these conventions are held, we have been welcomed to visit their foundries and thereby see what is being done. This one thing alone should inspire every foundryman to visit such conventions and it is also proving to us that the mechanical or machine end of the foundry is progressing rapidly.

Amongst the many mechanical appliances that have been invented for the foundry trade, the molding machine covers the largest field as far as output and economy is concerned, and is the greatest help in these days when molders seem to be getting scarcer. However, before we undertake to purchase a molding machine, let us look into a few of the details connected therewith. First of all, there is no reason why we should expect one kind of a machine to do all of our work, no more than the machinist who has to have a number of different machines to do his work. So with this in view we must consider well how we are going to equip our foundries further, in order to give us a fair return for our investment. Above all, don't think for a moment that we are going to run our foundries with machines and unskilled help—we need the molders and it would be to their advantage as well as to all others concerned if they would take more interest in machine molding. The day is coming and coming very fast, when the molder will be called upon to look more after the art, and the machines will do the laborious part of the work; then he will be looked upon as a thorough mechanic and be given a greater measure of respect than has been the case in the past.

Now, as to what kind of a machine should be purchased, that should be determined by ourselves. It's right and proper to get the advice of responsible machine manufacturers, but go and visit a few foundries that have machines and are making a class of work something similar to what you want to make.

At the same time, don't forget to think out how many different things you can make on a certain machine if you had it. There's many a time you might say I wish I had a squeezer, when by probably doubling up or by putting eight patterns on a board instead of two, you could do much better on a roll-over machine, and *vice versa,* and it is the number of castings you've got to make, combined with the different kinds of castings you can make on a certain machine, along with the cost of operating same, that should determine which to purchase (and don't leave your purchasing agent decide for you).

It would be needless for me to try and enumerate all of the different kinds of machines on the market at the present time. They undoubtedly are all good, but some better suited than others for certain classes of work, and it is for the individual buyer to see that he gets what is necessary for his requirements. In taking up a few of the more commonly used machines that I have seen in daily operation in over fifty different foundries, namely, the Power Rammer Type Machine, Split Pattern Machine, Power Ram and Power Draw, Squeezer Machines, Stripping Plate Machines, Blow Ramming Machine, Hinged Roll-over up or down Draw, Power Roll-over Up Draw, Gravity Molding Machines, Plain Jarring Machines, Combination Jarring Machines with roll-over and draw attachments, etc., I found that foundrymen were having a gain of from 50 to over 250 per cent. over hand methods in making molds and half-molds weighing from 50 to 50,000 pounds. The percentage of bad work is reduced to a minimum; so that when we compare the money investments on machines, the enormous gains soon pay for them. In my investigations relative to the repairs on machines, when they get out of order, I have found that the cost is very small, and in quite a number of cases some machines have been in constant use for one, two and three years and have practically cost their users nothing for their up-keep.

MOUNTING PATTERNS FOR MACHINES.

A great deal could be said about this subject, but every foundry has its own conditions to contend with, and it depends largely on the number of castings you have to make of any one kind, the size and weight of same, or if you have a special line

of work, above all give particular attention and avoid the laborious work on the man.

On the smaller machines, wood boards for mounting patterns permanently can be used to advantage, particularly on rollovers, as they are light to handle and cost considerably less than the brass or iron plate with dowel holes to match different patterns that you have to change. There will be less fins, and castings will be more accurate. As to stripping plates or frames, it is almost necessary to have them made in brass or iron with edges filled in with babbitt metal, although quite a number of wood plates or frames are used.

As to matches, the old sand match still holds its own, although there are a number of different compositions on the market now that are giving satisfactory results. On the larger machines, the wood follow-board is used very extensively, although some of the jarring machines are equipped with iron platens, the same having dowel holes to match a certain number of patterns and flasks to suit. Some again are equipped with stripping plates, which, as we all know, are a great advantage. In a word I may say that I believe the jarring machine will be the machine of the future for general work.

The more automatic machines are in a class by themselves and no doubt give an enormous and satisfactory output where they can be installed. It now being an established fact that the molding machine is performing a wonderful amount of service in the foundry, let us look at a few of the benefits that have been derived from it. It has raised the standard of foundry practice to a greater extent by the better all around quality of the castings made. Castings are more near uniform to pattern, at least from 10 to 15 per cent. in their weight is saved; in fact, it is only a short time ago since I read of a foundry saving over 25,000 pounds of metal in one year on one job alone.

Through the accuracy of the work of the molding machine not less than 5 to 10 per cent. of time in finishing in the machine shop is saved, and in quite a number of cases there is only grinding finish left nowadays. The molding machine has been the means of giving the pattern-maker a better knowledge of his trade and foundry practice, consequently raising his mechanical ability. The life of the patterns have been increased tenfold,

as there is little chance of the deadly vent wire, rapping bar and sledge hammer, or swabbing destroying them. Again, since we have had to get up a more accurate class of flasks and patterns for machine molding, it has forced us into doing the same thing for hand molding, and this has been the means of a saving in this respect.

Manufacturers in general who are making the most out of their foundries, are those who have changed and modified their designs to suit the molding machine and foundry conditions, and it would be well if those who are designing machinery would consult their foundry superintendent before settling upon definite plans. I cannot see how the foundry can help but be recognized as first in the mechanical trades, it's the first to produce the real goods.

We can now understand that molding machines and other mechanical appliances in the foundry should bear the same relation to the molder, as the different machines do to the machinist and pattern-maker. Therefore, if the molder feels disinclined to place himself in the position of machine operator, the only alternative I see is for manufacturers of molding machines to have instructors go around and train such men for the purpose, especially where they have installed machines. They should also give more talks at foundrymen's meetings.

I might say in concluding that foundrymen might establish schools where unskilled help can be trained in the use and handling of machines, at the same time advocating a more frequent use of the molding machine in all our trade and manual training schools throughout the country.

Get one now and "Hook 'er to the air compressor."

AMERICAN FOUNDRYMEN'S ASSOCIATION
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MANGANESE AND SILICON IN THE FOUNDRY.

By ALEXANDER E. OUTERBRIDGE, JR., PHILADELPHIA, PA.

In responding to the request of the Secretary of our association that I would contribute a paper for the convention to be held in Pittsburgh, on the subject of "Manganese and Silicon for Foundry Purposes," I have thought it advisable to confine my attention mainly to observations and investigations which I myself have made during my connection with foundries, extending over a period of more than thirty years.

In order that the progressive foundryman may clearly comprehend the remarkable influence that these and a few other elements exert (even when present in extremely minute quantities sometimes) upon iron, it is necessary that he should realize at the outset that iron when pure is always the same, physically and chemically, no matter from whatever source it may be obtained, and that all of the multitudinous variations the commercial metal exhibits, may be traced directly to the effects of combinations with a few other elements. In its pure or nearly pure condition iron is an exceedingly ductile metal which may be forged and hammered, or rolled, into very thin plates, ribbons or bars. Such bars may be bent double while cold, or tied into bow knots. The tensile strength is comparatively low, being approximately 50,000 pounds per square inch and the metal melts at a temperature between 3,000 and 3,500 degrees Fahrenheit.

The addition of a very small amount, or less than one-half of 1 per cent., of carbon (whose melting point is so high it has never been determined) lowers the melting point several hundred degrees and converts the metal into what is known as "mild steel," changing many of its characteristics and greatly increasing its tensile strength.

The addition of 1 per cent. of carbon gives us high-grade carbon "tool steel," having tensile strength frequently of upwards of 150,000 pounds per square inch, and possessing other new valuable properties.

By still further increasing the proportion of carbon the saturation point is passed and "cast iron" results therefrom. The tensile strength is again reduced and the melting point is still further lowered, the metal takes on entirely new characteristics and its chemical composition becomes far more complex by reason of the creeping in of other elements for which iron possesses very strong affinities. The adding of nickel, for example, is one of the comparatively recent developments of immense practical value, yet, strange to say, natural alloys of this nature have been familiar to metallurgists for a century or more, in the large meteorites that have fallen to the earth, perhaps from other worlds than ours.

Manganese in Foundries.

Manganese is a metal that for many years was regarded as a deleterious material which ruined the quality of iron or steel, yet this metal proved the salvation of the Bessemer process, and more recently Hadfield discovered that the addition of manganese in larger quantity than had hitherto been deemed permissible gave us "manganese steel," one of the most wonderful products known to man, possessing the rare combination of extraordinary strength, hardness and ductility.

About thirty years ago I commenced a long series of investigations with this element in connection with the special kind of cast iron used for making chilled cast iron car wheels. Formerly such wheels were made entirely from cold blast charcoal iron, a product peculiarly suited for the purpose. This metal was rich in carbon and comparatively poor in all of the other elements, viz.: Silicon, sulphur, phosphorus and manganese. Good car wheel iron has approximately the following composition: *Carbon, 3.242 per cent.; phosphorus, 0.403 per cent.; silicon, 0.776 per cent.; manganese, 0.391 per cent.; sulphur, 0.083 per cent.

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* The late Dr. Charles B. Dudley, former chemist of the Pennsylvania Railroad Co., generously permitted me to copy this analysis from his private records on the occasion of a visit to his laboratory in Altoona in the year 1881. The record states that this is the average analysis of drillings from five good wheels, which had given the remarkable average mileage of 122,463 miles in service. The average depth of chill in the throat was $\frac{3}{32}''$, in tread $\frac{11}{32}''$. The average tensile strength of the pieces cut from the gray iron in the wheels was 29,660 lbs.

Cast iron for chilled car wheels differs from iron for machinery castings or for general purposes mainly in its comparatively low silicon content, being less than one-half of the amount of silicon ordinarily found in iron castings and less than one-third the quantity often found in light castings such as pulleys. Nevertheless, the silicon in these good wheels was close up to the maximum amount permissible in chilled cast iron car wheels having the requisite depth of chill (or white iron) in the tread to insure high mileage.

The chilled cast iron car wheel is an American invention and the name of Asa Whitney* will always be inseparably associated with its history as a pioneer in its development and in its successful introduction in the early days of railroading.

As long as cold blast charcoal iron was obtainable, little difficulty was experienced in maintaining the product up to the required standard, and it is a remarkable fact that years before the chemical composition of the metal was studied or chemical analysis was used in preparing the melts, wheels were made in which the silicon (which is the most important element of all) did not vary as much as one-half of one per cent. from the average amount found by Dr. Dudley in the five good wheels, the explanation being that the foundry foreman was provided with a physical analysis of his metal in the form of "chill tests" made from every tap of the cupola. By this means the required depth of chill was maintained day by day.

In course of time cold blast charcoal iron became more and more difficult to obtain, "warm" blast was introduced for economy both in the quantity of charcoal fuel and in the time required for reducing the iron from its ore. Instantly the quality declined and then "hot blast" iron, made with anthracite coal, supplanted charcoal iron for almost all purposes, even the making of chilled cast iron car wheels. This change in practice necessitated the introduction of more scientific methods in car wheel foundries.

It was well known that manganese caused iron to chill, and as long ago as the year 1880 the custom of introducing a certain quantity of high manganese iron into the cupola in car wheel mixtures had already attracted attention. The tests which I was

* Born 1791. Died 1874. Mr. Whitney's basic patent for annealing chilled cast iron car wheels was issued in 1847.

called upon in that year to make convinced me that a "manganese chill" on the tread of a car wheel was a spurious chill, very handsome to look at, but poor in wearing properties. The crystals are coarse and lamellar, they "spall out" or break away from each other when subjected to repeated taps with a hand hammer. Moreover, the white iron caused by high manganese in a chilling mixture is comparatively soft and may be drilled without great difficulty. The result of introducing high manganese irons in the cupola proved disastrous in car wheels when put to severe practical tests and the rule was therefore made that a manganese chill must be avoided.

In the course of these early investigations, however, a remarkable discovery was made, almost by accident. I found that if a very minute quantity of powdered ferro-manganese was placed in the bottom of a ladle and ordinary car wheel iron poured upon it several curious things happened: First, a very rapid circular movement, or rather motion in ripples from the edge towards the center of the ladle, was immediately noticeable on the surface of the molten iron, this continued until the iron set, and was even apparent in the gates and risers of castings up to the moment of congealing. Second, when a chill test piece was fractured it was seen that the gray iron portion was very much darker in color and of more open grain than that of a similar test piece poured from the same iron untreated. Third, the white iron or chilled portion of the test piece showed no appearance of a manganese chill, the only visible change being a slight reduction in the depth of the chill. Test bars were cast from this metal and also from the untreated iron. An average gain approaching 50 per cent. in tensile and transverse strength was recorded.

Analyses were made by various chemists of drillings taken from the treated and the untreated iron. These all showed that the principal change caused by the treatment had taken place in the condition of the carbon, nearly one-half of the combined carbon had been changed to the graphite form. The sulphur was likewise decreased. The shrinkage of the test bars of treated iron was reduced nearly 30 per cent. as compared with the same iron untreated. Various proportions of ferromanganese (containing about 80 per cent. manganese) were

tried, with the final result that the rule was adopted that in each ladle, holding about 600 pounds of iron, needed at that time to pour one full sized 33-inch car wheel, one pound of powdered ferro-manganese should be used. For a number of years this method was adopted only in the car wheel works of A. Whitney & Sons, Philadelphia, but in the course of time it became generally known and used, and although my connection with work of this nature ceased in 1887 I believe the method is still very generally if not universally employed.

In an address given at the Franklin Institute in 1888, entitled "Pig Iron and the Relation Between Its Physical Properties and Its Chemical Constituents," printed in the Journal of the Institute in March of that year, I made my first public announcement of these investigations as follows:

"Manganese is commonly supposed to exert a hardening tendency upon pig iron, but experience has taught me to regard this as another mistaken notion, it undoubtedly produces a marked effect upon the character of the white crystalline structure. You may readily recognize 'a manganese chill' by its coarse lamellar or foliated filaments and by the tendency which it produces to form white iron or 'hard spots' in isolated places throughout the gray portion of a casting. Manganiferous pig iron has been used to produce chilled castings, but it does not make a durable wearing surface; the chilled tread of a car wheel, for example, produced by this method, presents to the eye, when broken through the section, a handsome appearance, but the white metal is comparatively soft; it may be easily bored, and, what is more serious, it crumbles readily under the impact of rapid shocks on the rail.

"A remarkable effect is produced upon the character of hard iron by adding to the molten metal, a moment before pouring it into a mold, a very small quantity of powdered ferro-manganese, say one pound of ferro-manganese in 600 pounds of iron, and thoroughly diffusing it through the molten mass by stirring with an iron rod. The result of several hundred carefully conducted experiments which I have made, enables me to say that the transverse strength of the metal is increased from thirty to forty per cent., the shrinkage is decreased from twenty to thirty per cent., and the depth of the chill is decreased about

twenty-five per cent., while nearly one-half of the combined carbon is changed into free carbon; the percentage of manganese in the iron is not sensibly increased by this dose, the small proportion of manganese which was added being found in the form of oxide in the scoria. The philosophical explanation of this extraordinary effect is, in my opinion, to be found in the fact that the ferro-manganese acts simply as a deoxidizing agent, the manganese seizing any oxygen which has combined with the iron, forming manganic-oxide, which being lighter than the molten metal, rises to the surface and floats off with the scoria. When a casting which has been artificially softened by this novel treatment is re-melted, the effect of the ferro-manganese disappears and hard iron results as a consequence."—*J. F. I., March, 1888.*

It will be observed from the foregoing that manganese acts in two different and opposite ways in cast iron.

When alloyed therewith in the cupola in considerable quantity, say 2 per cent. or over, it has a chilling and hardening effect, producing what I have termed a spurious chill of coarse crystalline nature, in contradistinction to the normal chill in a good car wheel which has a fine and closely interwoven crystalline structure.

When the alloy called ferro-manganese is added in a ladle of molten car wheel iron in the small quantity given (1 pound of alloy, containing about 80 per cent. manganese, in 600 pounds of iron), it acts not as an additional contribution of 0.133 per cent. manganese to the metal in the ladle, but simply as a deoxidizing and desulphurizing flux, cleansing the metal from impurities, softening it and greatly increasing the ductility and strength without injuring the chilled tread of the wheel.

It has been stated many times by others, during the past twenty years, that the introduction of this (unpatented) process proved of inestimable value in car wheel manufacture, especially when the very severe "Thermal Test" was devised by the Pennsylvania Railroad Co. (and afterwards adopted by the M. C. B. Association), some time after my ferro-manganese method was published broadcast through reprints from the *Journal of the Franklin Institute.*

It is a source of gratification to me to know that these early

experiments proved of lasting practical value to a very important American industry.

The fact that ferro-manganese was found to be so beneficial in car wheel practice soon led others to exploiting the alloy for general foundry purposes, but the conditions are here entirely different and in most cases this alloy is not only of no benefit, but is actually detrimental to foundry irons. I have already explained that it changes a large portion of the combined carbon in car wheel (or chilled roll) iron into the graphitic

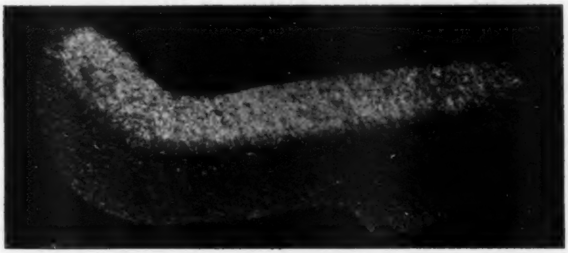


FIG. I.—SECTION OF 33-INCH CAR WHEEL CAST FROM TREATED IRON SHOWING FINE WHITE CRYSTALS AND DARK GRAY.

form, but this remarkable effect cannot take place in ordinary foundry iron which contains usually scarcely more than a trace of combined carbon. The ignorant and improper use of ferro-manganese in general foundries is sure to lead to disappointments.

An idea of the magnitude of the chilled cast iron car wheel manufacture in this country may be obtained from the following extract from an article by G. L. Fowler, on "Car Wheels," printed in *Cassier's Magazine,* March, 1910:

"Roughly speaking, there are about 2,250,000 freight cars at present in service on American railroads. Each one of these is carried by at least eight wheels, whose standard diameter is 33 inches, so that the total number of wheels in service is in the neighborhood of 18,000,000, and their value, at the lowest possible estimate, $180,000,000. This refers almost exclusively to the cast iron wheel, which is still the one that is the mainstay of

freight work, and which, until a few years ago, was the only one to be found under either passenger or freight cars. In short, it was upon the cheapness with which the cast iron wheel could be made that the very existence of many American railroads depended."

On referring for confirmation of the foregoing estimates to *Poor's Manual of Railroads* and also to the number of cars in the 1909 Report of the Interstate Commerce Commission I find that the figures are conservative and within the mark.

This does not include cars in Canada, Mexico, Central and South America and the large number of freight cars belonging to private corporations. Moreover: the estimate given of eighteen million car wheels, having a value of at least one hundred and eighty million dollars refers only to freight car wheels and takes no account of the enormous number of electric and mine car wheels, nearly all of which are made of chilled cast iron. This business has grown to immense proportions during the past twenty-five years and the use of ferro-manganese, added in small quantity in the ladles, has proved herein peculiarly advantageous and economical, since it permits the car wheel maker to cast all of these lighter wheels from the same mixture as is used for the heavy freight car wheels by simply softening the gray iron and reducing the chill to the requisite degree by varying the quantity of the alloy added in each individual ladle. Formerly it was necessary either to make separate melts for such wheels or to mix a certain quantity of soft iron, melted in a separate cupola, with the "regular wheel mixture," which was too high chilling for lighter wheels.

Very recently a pamphlet has been issued and widely distributed, setting forth the merits of a special brand of charcoal iron for car wheels in which the effort is made to disparage ferro-manganese, advancing reasons that are in my judgment entirely untenable, but, in doing so, the following remarkably strong endorsement of ferro-manganese is unwittingly given: "Up to the year 1880 the use of manganese had never occupied any particular place in car wheel practice except as it was found in charcoal pig iron. As previously stated, it took some years to bring the use of ferro-manganese into general practice, but as this increased from year to year, together with the elimination

of charcoal iron from many wheel mixtures, its influence became more and more apparent, its effects more in evidence after the introduction of 50-ton capacity cars and which exercised a powerful influence on the life of the chilled wheel. * * * The strength of the ordinary cast iron wheel of to-day is dependent entirely upon the use of ferro-manganese, and with its use there is no difficulty in meeting the 'M. C. B.' Specifications of 'drop' and 'thermal' tests." The objections referred to in the pamphlet have, I think, been fully answered. For example: thirteen years ago J. E. Cartwright, writing on "Manganese in the Foundry" said:

"Since Outerbridge made known the results of his experiments, the car wheel foundries, during the past ten years, have generally adopted the use of ferro-manganese and established the fact of beneficial results from its use in the class of work they make. The powerful action of a small quantity of finely ground or powdered ferro-manganese added in the ladle to chilling irons has gradually become known to them and one after another they have adopted its use, and the fact that, once adopted, they never change to their old practice, is good evidence that it yields results that are satisfactory. That there has been no deterioration, but, instead, a great improvement in the quality of car wheels made by the method now used, is shown by the fact that the severity of tests prescribed by railroads and the guaranteed life or mileage of wheels have been raised repeatedly during the last ten years, yet the car wheel makers have kept pace with these severer requirements and have no trouble in making wheels by this modern method that easily meet these higher tests and guarantees. The method followed by car wheel foundries is practically that described by Mr. Outerbridge."

When we consider the greatly increased weight upon the wheels, together with increased average speed of freight trains and far more severe action of the brakes in recent years, it is truly wonderful that the chilled cast iron car wheel should still be able to maintain its foremost place, notwithstanding the improvements made in steel wheels and great reduction in cost of their manufacture. The steel wheel will, in time, I believe, supersede the cheaper cast iron wheel for the severest freight service, but the day is far distant when the chilled wheel will no longer meet

the general requirements for rolling stock except for locomotives and passenger cars, and it is my firm conviction that as long as cast iron wheels are manufactured, the use of a small amount of ferro-manganese, added in the ladle a moment before pouring, will continue to be a standard practice, for it has long since passed the experimental stage and the recent attempt to create an impression that the introduction in the ladle of a minute quantity of manganese in the form of ferro-manganese (less in amount than the natural variation found in good car wheels made by different manufacturers, or even by the same makers) produces an objectionable manganese chill, will fail to make any impression on intelligent persons who understand the subject and have practical experience in the business.

Silicon for Foundry Use.

In a pure state silicon may be obtained in three allotropic forms, quite different from each other in appearance and also in some other properties. In this respect it resembles pure carbon which is found as "graphite," "charcoal" and "diamond." In the amorphous state pure silicon is a brown combustible powder. In crystalline form it has a red lustre, and in so-called "graphitic" form it resembles graphite in appearance. In recent years silicon has been produced in commercial quantity nearly pure (98 per cent.) by means of the electric furnace and is used in steel manufacture. Its melting point, however, is so high that it will not dissolve in molten cast iron in a ladle, as I have proved by many tests.

Formerly silicon was regarded as a most undesirable element in pig iron for foundry use, it was thought to produce "blowholes" and to make unsound castings.

When the suitability of pig iron for castings was determined by fracture only, as was the case in my early foundry experience, "Silvery pig" or "Rotten pig" or "Measly pig" as pig iron which was very high in silicon was variously called was practically an unsalable commodity to foundries, for, when silicon is present in quantity ranging from 5 to 10 per cent. or over, the pig metal becomes very brittle and hard, the fracture is very light gray in color and devoid of the crystalline structure characteristic of good

metal. It is indeed totally unsuitable for castings. I well remember the consternation among several foremen when I first introduced a car load of silvery pig iron containing 12 per cent. of silicon to their notice and proposed to use a certain amount of it in the cupola mixture for the purpose of softening the iron and permitting a larger proportion of hard scrap to be incorporated, followed by their astonishment at the unexpectedly beneficial result in the melt. My records show that for several years this high silicon iron was purchased and used as a regular component in the foundry.

In course of time the views of intelligent foundrymen changed with respect to silicon and therewith coincidently came a change in the practice of pig iron makers as well. No longer was it considered desirable to keep the silicon as low as possible in foundry irons, gradually the average proportion began to creep up, so that it was not necessary for me to continue to purchase 12 per cent. silicon pig iron in order to obtain the amount desired in our castings, for a sufficient number of brands of iron containing the full amount of silicon desired for our smallest castings could be obtained without difficulty at the ordinary market price of No. 2 plain iron. In fact, the pendulum has now swung the other way and I find it necessary to limit the proportion of silicon in pig iron purchases to suit various requirements.

The American Society for Testing Materials has fixed upon certain data with respect to the average proportion of silicon desirable for castings of various kinds, after consultation with foundrymen, metallurgists and chemists, and the information has been widely disseminated in its reports.

While experimenting with ferro-manganese added in ladles of car wheel iron many years ago I desired to know the effect upon the metal of other similar alloys and therefore obtained the highest grades of silicon alloys then made irrespective of cost, the richest contained nearly 20 per cent. silicon. It was a disappointment to find that even when this metal was powdered and preheated to redness the influence on the cast iron of the comparatively small amount that could be melted in a ladle of iron without making it dull was almost inappreciable. Similar tests were made with the metal aluminum which cost at that time $8 per pound, the results were again disappointing.

These experiments were therefore discontinued until the progress in the art of electro-metallurgy had made it possible to obtain very high-grade alloys of silicon and iron, when they were at once resumed on quite an extensive scale. The result of many tests showed that if an alloy containing approximately 50 per cent. silicon with iron is powdered and added in small quantity to a ladle of foundry iron (not over 1 pound of the ferro-silicon alloy in 200 pounds of iron, usually less than this) it melted readily without appreciably reducing the temperature and certain beneficial effects occurred. The metal became both softer and stronger, as may be proved by any one, in a simple manner by pouring chill tests and breaking tests from the same iron both treated and untreated. If, however, the molten iron already contains over 2.50 per cent. silicon there is little or no advantage to be obtained by adding this alloy in the ladle. As I have made the results of my investigations on the beneficial effects of adding high-grade ferro-silicon to cast iron known through a paper presented at the Cleveland meeting of the American Foundrymen's Association in June, 1906, and in various other publications, I do not think it necessary to repeat them here, but I desire to add in conclusion a word of caution to foundrymen.

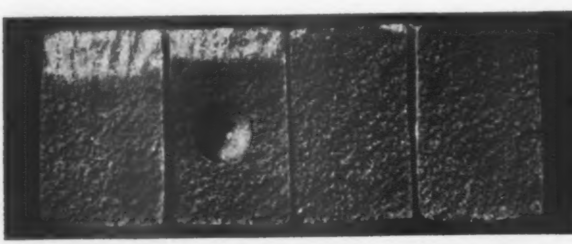


FIG. 2.—FOUR SPECIMENS CAST IN GREEN SAND MOLDS AGAINST A "CHILL BLOCK" ON ONE FACE.

Since the first publication of my experiments it has come to my knowledge that very impure adulterated material has been sold as 50 per cent. ferro-silicon alloy to foundries. In some cases the sweepings and dross obtained from manufacturers of ferro-silicon alloys have been bought in quantity at ridiculously low

prices, mixed with similar refuse from ferro-manganese manufacture, the whole being ground together to form a material which is of very poor quality indeed. The temptation to do this is great, the market price of 50 per cent. ferro-silicon is about 50 per cent. higher than that of 80 per cent. ferro-manganese and the two alloys resemble each other so closely that when broken into small lumps or grains, or powdered, chemical analysis is the only means of determining the relative proportion of each. The particles of slag, cinder and dirt may be readily seen in the worst samples by the naked eye or by the aid of a pocket magnifying glass.

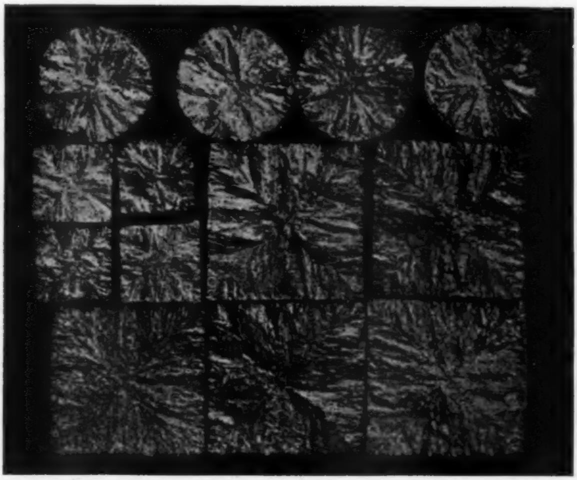


FIG. 3.—SPECIMENS CAST IN HEAVY IRON "CHILL CUPS."

The foundryman should understand clearly from what has gone before that ferro-manganese and ferro-silicon possess entirely different functions in cast iron and should not be used indiscriminately or in conjunction. Ferro-manganese is best adapted to the treatment of high chilling iron for car wheels or chilled rolls, or other chilled castings, where the proportion of combined carbon is large.

Ferro-silicon is best adapted to treatment of foundry iron

when from any cause it is hard and brittle, since it possesses the peculiar property of softening and at the same time strengthening such iron. It also enables the founder to vary the grade of iron in individual ladles to suit individual castings or groups of castings. It gives the founder control of his iron after it has been withdrawn from the source of melting, a matter of great importance and value, and it enables him to use cheaper grades of iron.

Finally, I wish to say that neither ferro-manganese nor ferro-silicon can be regarded as universal panaceas, as some unscrupulous salesmen would have the foundryman believe, and, while each in its proper place is of great value, they must, like all other good things, be used intelligently, and if impure adulterated materials are employed they will not only prove to be of no benefit but may be absolutely harmful.

The influence of silicon in softening pig iron and reducing its chilling property is clearly shown in Fig. 2. Four test pieces were cast in green sand molds, one face in each being formed with an iron block. The only important difference in composition between the specimens is in the amount of silicon in each. The one on the left contained 0.7 per cent. silicon, the one showing a hole where a drill had been used to obtain borings for analysis contained about 0.8 per cent. silicon. The next contained a trifle over 1 per cent. silicon, and the specimen on the right nearly 2 per cent. silicon. In this case a mere "skin chill" is noticeable on the upper face against the chill block. The remarkable effect of cooling gray iron very suddenly is shown in Fig. 3. Here the molds are heavy iron chill cups, some are ½-inch section, others 1-inch section, others about ¾-inch round section. All of these specimens are absolutely white iron. Samples of the same iron poured in green sand molds of about the same size were all perfectly gray in fracture. It will be observed that the white iron crystals always form at right angles to the chilling surface of the molds, presenting an appearance resembling spokes of a wheel in those of round section, and showing a cross at the nodal lines, or points where the crystals meet, in the specimens of square section. The lines of demarcation are as sharply defined as though scribed with a tool on solid metal, and it is possible, in some cases, to split the specimens lengthwise along these lines. The specific gravity of the gray iron is about 7.2 while that of the white iron

is nearly 8. There is, however, an appreciable difference in density of different specimens of white iron just as there is a well-known difference in density of different specimens of gray iron. There is also a marked difference in hardness of white iron crystals.

An effort has been made in this paper to present, in an informal colloquial manner, the results of some observations and investigations commenced many years ago and continued with few interruptions to the present day.

At the time of my first introduction to foundry metallurgy the total annual production of pig iron in this country was less than the minimum monthly production in recent years. The increase in capacity and daily output of blast furnaces, together with the change in kind of fuel, first from charcoal to anthracite, then to coke; the increase in the temperature of the blast; the decrease in fuel ratio; the change in character of ores, etc., have all caused radical changes in the composition and properties of pig iron and the old method of judging the character and grade of pig iron by "fracture" has now become obsolete.

In my youth a chemist in a foundry was generally considered as much out of place as a bull in a china shop, and my first effort to substitute scientific system for empirical methods was regarded by practical foundrymen with ill concealed amusement as a passing fad. The old order of things has now passed away and a new one has established itself on a permanent footing. What further progress will take place in the next thirty years I can neither venture to predict nor expect to witness.

ADDENDA.

A friend who kindly read the proof of this paper returned it with some rather interesting comments, viz.:

"Estimating that the total number of chilled cast-iron car wheels of all kinds made since the ferro-manganese process became known through your publication of March, 1888, in the *Journal of the Franklin Institute* and elsewhere is at least 35,000,000, and assuming that an average of 1 lb. of the alloy was used in the ladles for each wheel, the total consumption for this purpose was at least 17,500 tons.

"It was known during the lifetime of the Hamilton steeled wheel patent that the Pennsylvania Railroad Company, Messrs. A. Whitney & Sons, and probably some other car wheel makers, paid royalties of 50 cents per wheel on all wheels of 300 lbs. and over, and 25 cents per wheel on those of lesser weight, for the privilege of melting from 5 to 10 per cent. of steel scrap in their mixtures.

"Supposing that your process, instead of having been freely given as a scientific discovery, had been protected, and that the very small charge of 10 cents per wheel had been collected on only one-half of the foregoing estimated number of wheels made, the sum total would have reached the very respectable amount of $1,750,000."

I have found it impossible to obtain any data regarding these interesting estimates and calculations as to the annual production of mine car wheels and street car wheels, but official figures of the United States Census Bureau for 1900 show that there were "145,437 steam railroad cars" alone built in that year, requiring 1,163,696 new wheels. It is therefore evident that an estimate of 35,000,000 wheels of all kinds cast in twenty-three years must be considerably below the mark.

The statements of the American Iron and Steel Association show that in five years, from 1905 to 1909 inclusive, the production and importation for consumption of ferro-manganese amounted to 616,356.45 long tons, an average of 123,271.71 long tons per annum, so that the quantity used for car wheels is a mere drop in the bucket.

AMERICAN FOUNDRYMEN'S ASSOCIATION
PITTSBURGH CONVENTION
May 23–26, 1911.

MOLDING MACHINE PRACTICE.

BY E. H. MUMFORD, PLAINFIELD, N. J.

Molding machine practice includes two elements, the practice which the design of the machine involves, and the practice in its use, fitting the machine with patterns, supplying it with sand and disposing of the molds made by it.

In success, as in failure, it is sometimes one and sometimes the other of these elements which is to be held creditable or responsible for the result.

In both of these regards molding machine practice is a thing of change and its evolution from primeval conditions to present development has been so rapid that it is quite possible for one actively engaged in it to report progress and recount interesting changes almost annually without changing his caption and without claim to originality or more than ordinary powers of observation.

It is thus as a compiler of data concerning the work of many minds and hands and not as an author that I trespass upon your good nature.

Molding machine practice occupies a field, the foundry field, where for many years so little had been done that almost any mechanism advertised as capable of reducing cost and improving quality of work has found a ready market, especially as so many eager mechanicians have been ready to offer freely for trial, on the no cure no pay basis, apparatus about which their own enthusiasm has too readily become contagious among foundrymen.

It is almost a pity that foundrymen, like railroads, have not an Interstate Commerce Commission to decide for them what is worthy of their notice and what is not. Recently there was offered to our railroads and rejected by the Commission a mechanism of management christened by its promoters "Scientific," which they were assured could save them one million dollars per day. As a pure matter of salesmanship this beats any proposition in molding machines that has ever been laid before

our foundrymen; and yet, in a lesser way, our foundrymen are daily purchasing, on trial or guaranty, molding machines as to which the only basis for the investment is the enthusiasm of the salesman and the result repeatedly proves expensive to both.

If I were a foundryman I think I would suggest to my artless brethren the reference to a commission as wise in foundry equipment as the Interstate Commerce Commission is in railroad management, foundry machinery of all kinds for its judgment, or opinion, or experience. Such a commission would be as valuable to foundrymen who are now spending large sums on equipment as are consulting chemists or plant engineers.

The advice of such a commission would be as valuable to the sellers of molding machines as to the purchasers thereof, inasmuch as when in its opinion a new machine was worth trying, it would be tried on their recommendation in one or more foundries adapted to it and willing to make the trial, as to the result of which trial others would be advised, and the parallel selling, and too often parallel failures, rejections, and eventual burials of the devices with cost of repeated construction, transportation, foundations and operation would be saved. Probably, at least nine-tenths of the losses involved would be saved to our allied industries.

At present this identical kind of experimentation is being carried out independently and often simultaneously by many of our largest corporations, each for its own information. Consider for a moment what it would mean to concentrate in a conference committee or commission such an investigation, what it would mean to the manufacturer of the machine who builds and ships ten for trial when one might answer the purpose, and to the ten independent plants going ten times over exactly the same ground and eventually all ten coming to the same decision.

Such a commission might easily include in its functions the advice of expert patent counsel, exactly as do the railroads, to avoid risk of law suit, and most valuable of all, to prevent idle threats of patent suits based on vindictive competition retarding improvements and intimidating worthy originators of them.

During the past year, as during the previous few years, the most rapid development in molding machine practice has been

in large jolt ramming units, bringing into play suddenly and without time for proper consideration, problems of transportation and foundry apparatus without the solution of which these machines cannot do their best. It was recently my experience to sell a machine costing somewhat less than one thousand dollars, where I was party to a conference in which it was decided to appropriate ten thousand dollars to the equipment of cranes, molding floors, runways, flasks, match boards, etc., to properly take care of this single machine.

Had the machine been sold to operate, we will say, under an old-fashioned jib crane, it is doubtful if the installation of the machine would have been considered successful or worth while. With the large investment for facilities mentioned, the machine itself, if it might be considered alone, returned more than its own cost each month and the entire plant paid for itself within a year. These figures, taken from actual recent practice, may serve to illustrate the great advantage of trained and co-operating experts in foundry equipment, such as above advocated and the advantage of such advice to both the seller and the buyer.

It will need no proof to those of my hearers who have large jolt ramming machines installed, that there is not a jolt ramming machine of even medium capacity, worked to even a fair proportion of its possible output in rammed molds anywhere to-day. Jolt ramming machines are to-day in use in which the shoveling of fifteen to twenty tons of sand by hand can be practically eliminated by the use of a grab bucket on a crane, and in spite of the fact that two or three of our large foundries are using such a facility, the practice has not been as generally adopted as it would be on intelligent advice from such counsel as proposed.

Too many of our foundrymen are fond of buying machinery, and it is often disheartening to one who believes in simple single handed units, to find that a competitor, by a display of complicated and, therefore, often wrongly considered ingenious mechanism, producing a large concentrated output from a disproportionately large number of men, has taken the order from a foundryman who has been hypnotized out of his normal common senses by figures which deceive him, and wheels, levers, springs and plungers, to which he will often point with pride. A less

impressionable man believes in simpler units operating without confusion and unostentatiously laying down large single floors. He finds more profit in these handy floors than in the deceptive acreage covered by one machine and many men with much confusion, sweat and noise. The installation of the simple plain jolt ramming machine on massive foundations still continues, and machines designed to prevent floor shocks in foundries, necessarily more expensive and more complicated than the single machines, have not yet found their market We have, therefore, not yet attempted to introduce a machine of this type which we have designed and which is totally devoid of springs, flexible connections or valves mounted upon moving parts, but which nevertheless in the light of experience with the simpler machines has not seemed worth while.

Experience seems to prove that floor shocks are not destructive to ordinary molds set upon bottom boards standing loosely on the more or less cushioned sand of the foundry floor, while copes on bedded floor work may suffer severely. It is idle to deny, and it never has been denied, that there is a vibration of the earth in the vicinity of heavy jolt ramming machines, but twelve foot water pipe have recently been rammed on swampy ground in a shop where green sand copes of various kinds were prepared nearby, and the nightmare inspired by the advocates of machines which produce no shock vanished in the reassurance of experience.

There has been no advance in the past fifteen or sixteen years in the speed of molding machines on bench work per capita. Machines of the hypnotic kind above referred to, giving large output from single sets of patterns at a labor cost no lower, but often higher, than the simpler machines, have been sold, worn out and abandoned; and such machines continue good sellers and are highly thought of while their use and good health continues. There are instances where exceptionally attentive and able mechanics in charge of foundries to-day find such machines more profitable than the simpler machines, yet were they to furnish to the ramming and pattern drawing elements of these simpler machines the same facilities they furnish to the more complicated machine, they would be surprised to find that their improved

results were due to their intelligent provision of facilities rather than to the machines themselves.

The advances in machine molded bench work have all been in connection with sand supply and mold handling, and it may be worth while to note again that the output of a single hand-power machine may be trebled or even quadrupled by such facilities in any plant where the cost of the facilities is worth while. These great economies are found universally in specialty shops making such castings as air brake parts or pipe fittings and have not yet become so common in ordinary production of duplicate castings as they are destined to become within the next few years.

The net results in good molds being about the same from the many makes of the most efficient machines, the following may be taken as the considerations worthy most attention in the selection of these machines for general foundry practice.

First, breadth of application.

Second, precision of work.

Third, cheapness of pattern and flask equipment.

Fourth, durability.

The fourth consideration has in it two elements, those of strength and wear. It should be considered that it is especially true of molding machines that the wear of an important function, such as pattern draft, and its deterioration therefrom should not be aggravated by wear from a grosser function such as ramming. Machines, for instance, which ram and draw on the same guides overwork these guides and incapacitate them for the delicate function of pattern drawing while these would still continue serviceable for ramming.

Although this consideration does not strictly belong here, it seems appropriate to here remember that it is not good foundry practice, from a mechanical standpoint, to put so rough an element as an old foundry bottom board in the line of pattern draft. When such a board has been sprung by ramming pressure, so that it recovers when the patterns start, this becomes all the more true. That such boards are, by the contrivance of the builders of the machines and the patience of their users, used with moderate success does not prove anything, except that there

is much in man which cannot be expressed in formula or in mechanism which triumphs over mechanical failure otherwise assured to the unintelligent functioning of machinery, as to those who would by methods miscalled "scientific" ignore the intelligence and co-operation of the mechanic, often as intelligent as his employer as to his efficiency, and the best helper an intelligent employer can find.

GAS CAVITIES, SHOT, AND CHILLED IRON, IN IRON CASTINGS.

By Thos. D. West, Cleveland, O.

About eight months ago, at the request of the writer, the Foundry Journals and Iron Trade Papers of this country and Europe kindly published an article soliciting samples of iron castings showing globules in gas cavities, solidly encased shot iron, hard streaks or spots in castings, and white areas inside of gray or soft iron. Those good enough to forward such samples were requested to give the following information:

First.—The character of pig, scrap, fuel and any flux used in melting the mixtures. Also if anything unusual occurred or was observed during the heat. Grade of the iron produced, whether soft, medium or hard, or better still an analysis of the casting and the defects, whether shot or white iron.

Second.—A rough sketch of the casting showing its shape, and the thickness of the different sections as far as possible, marking the location of the defects on samples forwarded.

Third.—Whether the mold was of green sand, skin dried, dry sand, or loam, and a description of gating and pouring.

Fourth.—Whether the metal at the time of being tapped, as well as being poured into the mold was "hot," medium, or "dull," and any other information that might be thought of value in assisting an intelligent research of the subject.

Shot Iron in Castings and Experiments to Produce It.

Losses by defects as stated in the subject title above have caused many firms much worry and trouble before they could be made to disappear. The greatest annoyance, however, would arise from the fact that the trouble would be abated, but its origin could not be traced, and hence intelligently guarded against thereafter. As one of the letters received by the writer from a prominent Massachusetts firm is very pertinent, an extract from it is given herewith:

"We note that you are accepting samples and suggestions

regarding the formation of hard shot in cast iron and think, perhaps, some of our experiments will be of interest to you. From time to time we have had trouble with this shot forming in castings which we have made. A great deal of this work is finished, and as shot in it is always sure to knock out the forming tools, so that they have to be reground, we have tried almost everything to stop this, and even when it does stop we do not know what we have done to do it.

"We conceived the idea of trying to make this shot in the iron, thinking that perhaps if we found out how to make it, we could then see how to stop the trouble. Our chemist informed us that the 'shot' was caused by the foundry 'mesh bugs' or small particles of chilled iron that drop in the meshes in the foundry. These, he stated, trickled down through the charges and were not properly melted and run into the molten metal, in this way forming the shot.

"We took some of these bugs and put them into the ladle and poured castings from them, but were unable to make any shot. We also tried hard rattling stars, small set screws and small pieces of steel and were unable to produce any shot. We tried putting these hard materials in the mold and pouring the iron in the mold on top of them, but with the same result, no shot. We then wet a gate in the mold in an attempt to make the mold blow, without results. Damp, wet sand, while it caused blow holes, did not produce the hard shot. In fact we have tried everything that has been suggested that might cause this trouble, trying to make the hard shot, making the test as favorable to the formation of them as possible, and have been unable to produce anything. We are therefore coming to the conclusion that there must be something in the mixtures of iron, and are going in on that basis to try to cure it, although at the present time we have not had any trouble. We have no samples to send you, but should any come along that show this formation, we will forward them to you."

Another experience along the line of the above firm is given by a large concern in New Jersey, in the following extract, taken from a lengthy letter giving experiences, mixtures, etc.:

"The castings were nice and soft, and the only trouble, which,

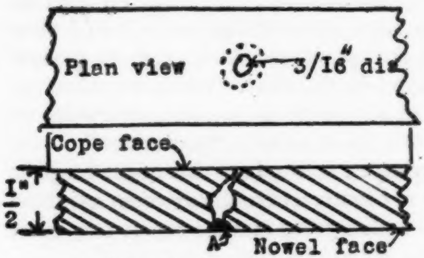
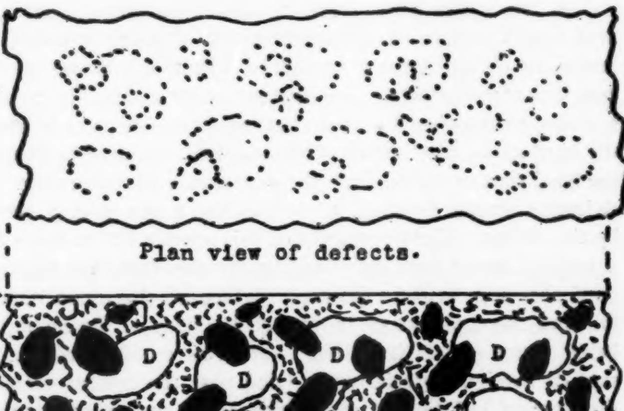
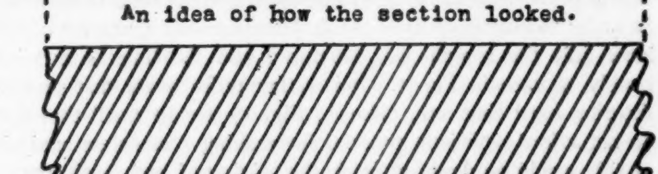


Fig. I.

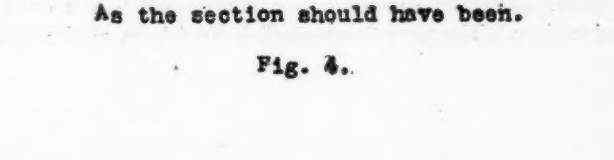
Fig. 3.



Plan view of defects.



An idea of how the section looked.



As the section should have been.

Fig. 2.

however, was serious, was with the small, hard shot. At one time we were using hard iron stars for cleaning, and some of these stars got mixed up with the sprues and scrap, and we thought the hard spots were caused in this way. However, when we eliminated all possibility of a mixture having hard iron stars we still had the trouble with the hard spots in the castings."

The above two experiences, with others that might be given in addition, would suffice to counteract the theory often advanced that small chilled or hard bodies going into the cupola may cause hard shot, streaks, or spots in the iron castings.

Shot Causing Hard Spots and Blow Holes in Iron Castings.

A few weeks after receiving the Massachusetts letter, this firm sent a sample of defective casting showing a small, hard button or "shot" loosely embedded within the nowel or down cast face of its surface. The sample (illustrated in Fig. 1) shows a crease made when the tool swerved off to one side in striking the hard spot. Also the chiseled indentations caused by removing the hard shot or button from the planed face of the casting. This defective sample is about as interesting a one as any received by the writer. The peculiarity of this sample lies in there being a vertical, small blow hole leading directly from the top of the hard shot seen at A to the cope surface, so that upon removing the shot one could see clear through the body of the casting, this being about a half inch thick. It gives evidence of the hard shot or foreign material while lying near the bottom surface of the casting emitting a gas which went upward through the molten metal to the sand surface of the cope, but not sufficiently fast to prevent the creation of the small, vertical blow hole shown. In order to clearly observe the full surface and character of this blow hole the sample was fractured and the hole is sketched closely, as seen in Fig. 1. It is rather unfortunate that samples showing hard shot, etc. (like A, Fig. 1) are so small that they do not afford sufficient material for making a complete analysis, as this would no doubt assist in the solving of such problems.

Several samples of soft iron castings have been received containing solidly encased or cemented small bodies of strictly white iron. The term "cemented" is used here, as the spots, or

white bodies, are in no wise loose in the casting. They form a part of it, showing differences in color of white and gray, but are as solidly united as this is possible for any two plastic materials, each of a different grade and color, to be so. Not only is this defect obtained in a shot or spot form by founders, but also in streaks and bodies of considerable area. Defects of these characteristics are most generally found at the upper cast body, face or edge of castings.

Experiments with Shot Iron Placed in Molds.

Some shot iron was received by the writer which had been taken from a cupola spout after the bottom was dropped, on the supposition that it could cause blow holes. Some of this shot he placed in the bottom of an "open sand" mold giving small castings, about three-eighths inch thick. In pouring these, no disturbance of the metal through any escape of gases was noticeable, and when the castings were broken through sections containing the shot they were perfectly sound. The writer also used some of the shot by placing it on the bottom of closed molds, and pouring some of the molds with "hot" and also with "dull" iron. In one case of "dull" iron, a very small gas cavity or blow hole was barely noticeable above the top of the shot. The party forwarding the shot stated none were observable at the first of the heat when nearly all pig iron was being melted, but noticed them at the latter part of the heat when the charges were composed largely of scrap iron.

The above shots were sufficiently soft to be squeezed or flattened slightly before cracking by placing them between the jaws of a vise and applying pressure. The experiments conducted by the writer showed, aside from the "blow" question, that unless shot iron was up to a very high red heat, or near the fusing point (as is possible in many cases when they are formed in pouring a mold), that casting metal under three-eighths inch in thickness would have little effect in melting them, unless they might rise to be embodied in nearly the middle body of the casting, especially if the shot are roughly over one-eighth inch in diameter. The shot which the writer used in the above experiments were placed on the bottom face of the mold at the end

farthest from the pouring gate, so that the wash of the metal would not be so liable to disturb them. An examination of the castings when cold showed the shot in their original position and not united to the body of the castings, when fractured along a line in their position.

Causes for the Creation of Shot Iron in Castings.

The logical reasoning regarding the creation of the small, hard particles or metal shot found in some castings, is that they become suddenly separated from the general mass of metal during the pouring of a mold. When thus separated they solidify so

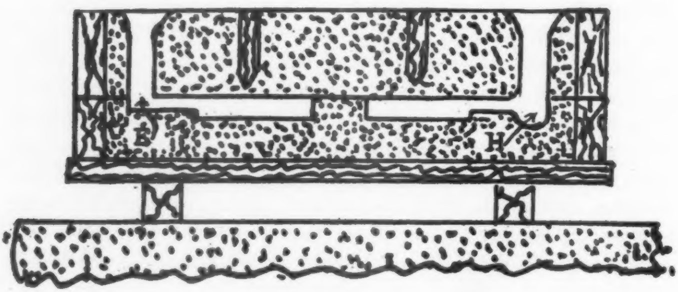


Fig. 2.

quickly that not sufficient time is given for the carbon to be separated out as graphite. Hence the shot does not have the softness of the rest of the casting which had more time to cool.

The longer the distance a shot is sent through the air before it lodges and the cooler the air it passes through, the harder the shot. Affecting this also is the degree of dampness of the spot upon which the shot may lodge. Where shot is caught and covered by incoming metal before it has time to become cooled below a red heat, the chances for their being hard and discoverable in a casting is not of course nearly as great as when they can become of a dark color before being encased by the liquid metal.

Particles of iron or shot may be formed during the falling of the metal from the ladle's pouring lip by striking the sides of

a pouring basin or gate. Again, by falling upon a flat bottom inlet gate, as at E, Fig. 2. Or when the metal reaching the mold strikes some obstruction fronting the gates to splatter the metal. In ordinary plain work there is probably no feature so harmful in causing a splattering as having flat gate bottoms, as at E. The bottom of all pouring gates should have more or less of a well, as at H, Fig. 2, as by this formation, if there is hesitation for a moment or so when starting to pour, the first droppings from the ladle fall into the well shown, to stay there in a liquid bulk and not be spattered to create shot.

In starting to pour the majority of molds, especially those of a light work and stove plate character, there should be no momentary stoppage after starting, but from the instant the falling metal first strikes the bottom of a gate, as at H, there should be a steady and unbroken stream to rapidly fill the pouring gate and have it kept so until the mold is filled. This applies to the flat top pouring gates generally used for stove plate, etc., as well as those of the joint character, shown in Fig. 2. Following of the above practice closely in all admissible cases should help greatly to end some of the trouble experienced with shot iron and hard spots in castings, and is one illustration of where the master's skill in handling a ladle can be displayed.

Dampness and Sudden Cooling Causing Chilled or White Iron Bodies and Shot.

The too free use of a swab or sponge in wetting the joint of a mold, before drawing a pattern, or after this is done in finishing a mold, can easily harden or chill the metal parts of a casting formed where this excessive dampness existed. Again, also, by too damp a mixture of sand, hard ramming or insufficient venting. Metal striking these damp sections will often bubble and splatter to a greater or less degree. This action can in some cases create suddenly chilled shot that will be carried to other sections of a mold to become encased in liquid metal and thereby give the white iron or chilled shot found in some castings.

The above is not intended to account for all the white iron, chilled shot, streaks, etc., found in castings, especially those of a light work and stove plate character. However, a solution of

the phenomenon seen in Figs. 5 and 6 relating to "inside chill" should greatly help founders to prevent some of these annoying and costly experiences.

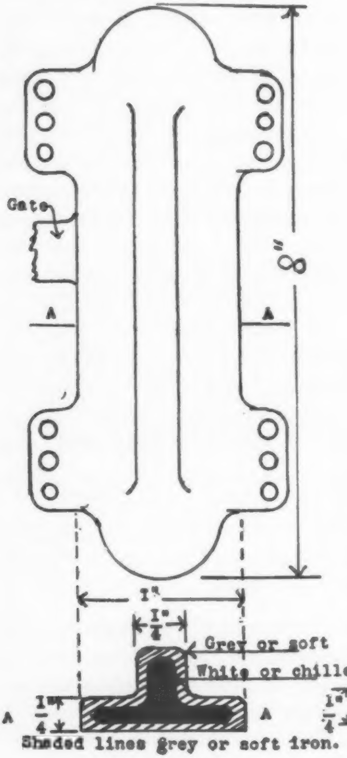


Fig. 5.

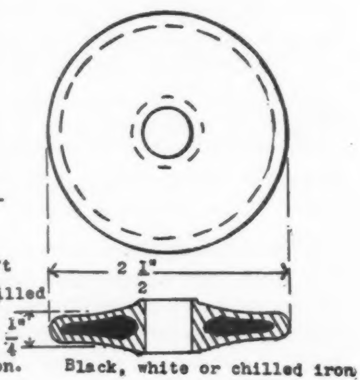


Fig. 6.

As white iron or hard spots can be produced at will in gray iron castings, especially those of a light character, by the immoderate use of the swab or sponge, damp sand, hard ramming and insufficient venting, this would indicate that the skilful, broadly experienced overseer and molder can master many troubles along these lines.

Where Much Responsibility Rests.

While we have both the melting and molding end of a foundry to watch in order to discover many of the troubles cited herein, it is to be said that the lack of a capable overseer, as well as of well-trained molders is often responsible for their creation. Again there should be no division of responsibility. The head foreman or superintendent should be a master of mixing and melting, as well as of molding. The opportunity for shifting this from one to the other may easily cause the overcoming of these evils as well as others to be a very difficult task, the proprietors or stockholders paying the losses while contention lasts.

Creation of Globules in Gas Cavities and Blow Holes.

The next defect to be taken up is that of globules in gas cavities and blow holes, an illustration of which is seen in Fig. 3. These defects can be due to two conditions but emanating from one cause, and that is the creation of excessive gases or steam that cannot find its liberation from imprisonment within a body of solidifying metal. They are found chiefly in the upper body or cast end of castings.

Excessive gas, causing blow holes or cavities, may come directly from the metal or wholly from defects in molding or pouring. Those due to the iron may be caused by oxides of iron or manganese reacting on the iron's carbon, the former producing carbon mon-oxide gas, or on liberated graphite creating kish (although of the latter there is very little in remelted iron, it being chiefly found in direct metal at blast furnaces). Also indirectly through sulphur, by reason of the formation of sulphide of manganese. And again by a foreign body like that possibly created by the mixture of iron oxide and dross (the latter may contain some kish in connection with the dirt generally coming from clays of the cupola tap hole and spout, and other sources) forming a slag on the top of a ladle's metal that could pass in small bodies into a mold at the starting of pouring, or later on before a mold is filled, through defective skimming. Thereby often large as well as small blow holes or gas cavities are formed. As a side issue it can be said that a ladle's surface

dross can easily cause dirt holes, pin holes, and a dirty surface to the finish parts as well as the rough surface of castings when skimming is at fault in pouring a casting.

Gas cavities and blow holes due directly to defects in molding and pouring are often due to not having properly tempered sand, regulated degrees of hardness in ramming, efficient means of venting, and correct methods of finishing cores and molds, combined with needed experience in gating and pouring. These are all factors demanding the experience of a decade or more in the actual work of general molding, in order one may be fairly qualified to best prevent the occurrence of the difficulties treated herein, or to stop them quickly when in evidence. The truth of all this is demonstrated by the difference in the soundness or perfection produced in castings by the master molder and the one that is not.

Molding Machines Versus Defective Castings.

It may be asked whether molding machines would not assist in preventing some of the above defects. Molding machines, owing to the following of an exact routine, adopted after much experimenting as the best to insure desired results, cannot but be helpful to a large degree in removing the liability of steam and gas cavities, or blow holes, chargeable to molding. This is not saying that they will remove the liability for all the defects treated herein, or that there is no demand for the master molder or the research and knowledge such a paper as this imparts, as these can and will be greatly utilized as long as there is a demand for castings or the need for melting iron.

Defining Whether Globules Are Due Defects in Metal or Molding.

Globules when suspended from the roof of a cavity, as at B, Fig. 3, are evidence that the cavity is probably due to something being wrong in the method or manner of making, gating or pouring the mold then directly with the metal. The mold's gases or steam creating these cavities may be originated during the

filling of the mold, and again may not until sometime after the mold has been filled, or before the main bulk of its metal has solidified. Imprisoned gases or steam, due to defects in molding, form a cavity into which the outer body of liquid metal may with favorable conditions ooze to form loose shot or suspended globules, as seen at B, Fig. 3. The actions of globules or any liquid, also any special elements, finding access to such cavities may continue at intervals for a short time after a gas cavity has been formed, or as long as the body of metal surrounding the cavity remains in a fairly liquid state. The larger the cavity the greater the chances for this action. Globules finding access to a gas cavity at its upper end, as displayed in Fig. 3, may be credited to the law of specific gravity and also to the condition that heat rises and that the upper body of metal is as a rule more fluid than the lower, as is evidenced by the "hot spot" or shrink hole being the greatest in the uppermost cast end of castings.

Cavities created solely through conditions of the metal, or its constituents, or again strictly by splashes of oxidized bodies of metal, or foreign solid matter should by logical reasoning more generally present an unbroken smooth bright surface. The metal, or confined oxidized shot conditions that start these cavities are such as can in some cases continue the creation of gases to make a higher internal pressure to prevent globules, liquid metal, etc., entering their space than exist where gases become imprisoned from a source that cannot add to their volume, or increase their pressure, as would more generally be the case if created wholly by defective molding.

A casting may possess gas cavities that will be due to causes inherent in both the mold and the metal. This for one case, as an example, could occur through a mold bubbling or boiling its metal sufficiently to throw up small bodies or buttons of metal that would fall back oxidized into rising metal in the mold, and these bodies, buttons or shot could, by reason of their oxidization and probable gathering of dross, create a gas to cause cavities that would be companions to those created solely by the mold's steam or confined gases endeavoring to escape, but was imprisoned in the metal. (See Fig. 4.)

Sulphur and Phosphorus Causing Blow Holes a Weak Excuse for Such Defects.

It is possible that sulphur or phosphorus may create blow holes, or the globuled roof perforated gas cavity, but with my experience of forty-eight years as an active molder and shop manager, making all kinds of castings in green sand, dry sand and loam work, knowing something thereby how castings can and should be made, I have little faith in the common "chestnut" excuses of sulphur or phosphorus forming blow holes in gray iron castings. In thinking back over my long years of experience I cannot remember ever having seen a blow hole or gas cavity in a strictly gray iron casting that I could believe came from any other cause than defects in molding. With castings that have come under my own making or supervision having blow holes or gas cavities, I always proved this faith by the discovery of defects in their molding, etc., and making changes in the work that would stop them.

Where mixtures are of a hard or chilling iron I stand ready to more seriously consider the sulphur and phosphorus excuses for blow holes or gas cavities, etc., in castings, but for soft or gray irons I desire to maintain the above position until it is positively proven I may be in error.

Among the letters that have come to my hands for consideration of this subject is one from Mr. P. Munnoch, of the British Foundrymen's Association, and as it presents some excellent information obtained by hard research work I take much pleasure in presenting the same in the following twelve paragraphs and three tables of analysis:

Metal Shots and Buttons in Gas Cavities of Iron Castings.

"The chief peculiarity noticed in connection with shot is that they usually occur in the upper portion or near the upper surface of a casting. Generally they are small in size and almost round. In some cases they entirely fill the cavity in which they are formed, in others they only partially fill the cavity."

"When fractured the appearance varies from gray to white. When machining castings the tool will usually jump over the white variety as this is extremely hard."

"The analysis given in Table I shows the composition of shot and buttons and also composition of castings from which these were taken. They are arranged according to phosphorus content. Several of these analyses were mentioned in a paper entitled 'The Practical Application of Chemistry to the Foundry,' read before the British Foundrymen's Association, August, 1908, by the writer. They were also mentioned in a paper on 'Iron Sulphur and Phosphorus,' by J. E. Stead, at the same meeting, see the 'Foundry' for September and October, 1908."

"Most of these analyses are from specimens obtained from large castings. In some cases several ounces in weight were obtained, the holes from which they were taken being very much larger than the buttons of metal found in them."

Shots Liquated from Solidifying Metal.

"My first experience was with gray shot enclosed in small castings. The small sizes of these shot yielded metal for partial analysis only and did not reveal anything to any great extent different to the analysis of the casting from which they were obtained. In some cases these were apparently shot of metal splashed into the mold at the commencement of pouring, and then after oxidizing on the surface became enclosed in the liquid metal. Afterwards I came across some peculiar castings, from which I obtained large buttons and pieces sufficient to make complete analysis from. The analysis showed that these could not be merely splashes of the original metal, but must have been liquidated from the interior of the casting after the greater part of the metal had solidified. The analysis of the buttons appeared very similar to that of the metal drops squeezed out of phosphoric pig iron after the metal had solidified, by submitting it to hydraulic pressure, in some early experiments by J. E. Stead, F.R.S. I therefore submitted some of the specimens and analysis to Mr. Stead, and his opinion was that blow holes were first formed, and these afterward became filled with the highly phosphoric liquate. I examined castings from various sources and found all more or less troubled with this defect. I obtained many specimens, in some cases sufficient for complete analysis, in others hardly sufficient for a single determination."

Obtaining Large Shot or Buttons from Gas Cavities.

"Some large cylinder heads for blowing engines supplied many interesting specimens, pieces several ounces in weight being obtained. In some cases pieces or buttons of different compositions were obtained from different parts of the same casting and pieces of different compositions were found in the same cavity. The castings weighed about ten tons, the thickness varied considerably and the molds were largely built up of cores, some of which were difficult to vent satisfactorily. The castings were square, with a circular web and flange running around the top, and the holes were formed in the top flange. The holes were only revealed after machining and after removing a good thickness of metal. The holes were large and the interior in most cases was bright, but in one or two cases small masses of oxide were found. The upper surface was smooth with rounded projecting crystals indicating the rising of gases after a considerable thickness of metal at the top of the mold had set. The lower part of the cavities showed signs of shrinkage in places, but the bottom was usually covered by the liquidated masses."

The Form and Character of Buttons and Shot.

"The buttons themselves were smooth, with a bright mirror-like surface, which they retained after several years' exposure to the acid fumes of the laboratory. The buttons were rounded at the edges and therefore could not have been very fluid when run. In some cases small shot were partly enclosed by larger masses, and this, together with the difference in composition, showed that the liquidated metal had not all entered the cavity at the same time, but at different periods of solidification. In some cases the small shot present appeared to have been squeezed into the cavity. The gray shot were similar to the casting in fracture, the mottled shot not unlike ordinary mottled iron, the white was much like white iron, but the outside part showed a crystalline appearance in the form of long crystals interlaced and partly covered with a thin layer of graphite in some cases."

"There was evidently a contraction of the outer shell or expansion in the interior set up after the metal was almost solidified and the pressure set up caused the still liquid portion to be

squeezed from between interstices of the already formed crystals, into the cavity formed previously."

High Phosphorus Shot.

"For comparison, analysis of liquid which is squeezed out of low phosphorus forge pig iron is given in Table III. In this case the exterior is solid and the contraction of the shell or expansion in the interior forces out some of the still liquid metal from the interior. In the case of the castings it is not the still liquid metal which is forced into the cavities, but the phosphorus enriched liquid remaining in the spaces between the crystals, at the time when the pressure is set up. The liquid is gradually enriched in phosphorus until the phosphide entectic containing 6.7 per cent. phosphorus, 2.0 per cent. carbon and 91.3 per cent. iron is reached, and the amount of phosphorus in these buttons is an indication of the period during solidification at which they were formed. The shot in which the phosphorus is very little different to that of the castings may in some cases be due to splashes of metal entering the mold at the commencement of pouring, becoming coated with oxide and becoming simply encased in the following molten metal. Or shot may be formed by a compressive action similar to that illustrated in the case of forged pig iron in which a portion of the still liquid metal in the interior of the casting is squeezed into a previously formed hole. In this case composition would be much the same as that of the casting in which it is found. This is an example of shot that might be formed in the outer solidified part of a casting the interior of which is still liquid. In the case of high phosphorus shot, the liquate enters the hole after the casting has practically assumed the solid state. The last portion of a casting to become solid, the interior for example, is not found to contain more phosphorus than the outside parts of the same castings, in fact in spongy parts of a casting the opposite is sometimes the case, as the phosphorus enriched liquid between the crystals has to some extent been drained away."

Effect of Oxidizing Condition on Metal and Shot.

"Generally the formation of shot holes and shot are most noted in iron which has been subjected to oxidizing conditions

during melting. Instances of this may be seen when the first metal from the cupola runs cold, particularly when the softer varieties of iron is being melted. If this is caught in a ladle and allowed to solidify it often presents the appearance of a spongy mass full of shot, the holes and shot being coated with oxide and graphite. Should some of this be left in the bottom of the ladle and some hot fluid poured over it, a boiling action follows, and if poured into molds the castings produced contain many holes of the shot hole type. Holes of this kind may be bright or tinted inside, they usually contain specks or flakes of graphite and often contain particles of oxide in the lower part."

TABLE I.—ANALYSIS OF "METAL, SHOT AND BUTTONS" FROM CASTINGS.

	1	2	3	4	5	6	7	8	9	10
Fracture.	White.	White.	Mottled.	Mottled.	Mottled.	Mottled.	Mottled.	Gray.	Gray.	Gray.
Graphite Carbon	......	.33	1.16	......	......	1.68	2.02	2.44	......	2.45
Combined Carbon	2.20	2.00	1.25	1.00	......	1.05	.75	.76	......	.85
Silicon	.70	.84	.93	.60	.86	.93	.98	1.26	1.14	1.32
Manganese	.63	.59	.48	.63	......	.36	.50	.45	......	.43
Phosphorus	5.68	5.45	4.88	4.84	4.64	3.80	3.20	1.92	1.80	1.70
Sulphur	......	.016	.031	......	......	.021	.037	.046	......	.031
Taken from casting	B	B	B	D	E	C	F	F	E	A

TABLE II.—ANALYSIS OF CASTINGS FROM WHICH SHOT WERE TAKEN.

	A	B	C	D	E	F
Graphite Carbon	2.74	2.80	2.90	3.25	2.80	2.85
Combined Carbon	.62	.50	.40	.05	.60	.60
Silicon	1.63	1.72	1.70	1.77	1.95	1.65
Manganese	.51	.49	.45	.44	.48	.49
Phosphorus	.88	.83	.89	1.23	.95	.84
Sulphur	.091	.118	.114	.107	.105	.119

All the above analyses were cylinder heads except E, which was a pedestal.

TABLE III.—FORGE PIG IRON (LOW IN PHOSPHORUS) WITH PORTION SQUEEZED OUT.

	(Pig Iron.)	(Liquate.)
Graphite Carbon	3.06%	3.30%
Combined Carbon	.78%	.58%
Silicon	1.23%	1.30%
Manganese	.78%	.82%
Phosphorus	.043%	.046%
Sulphur	.091%	.034%

Effect of Contraction in Compressing Metal.

"At blast furnaces where low phosphorus pig iron is produced it is noticed that after the iron is run into the pig molds and the metal appears to be solidified on the outside, the still liquid portion in the center squirts out and forms small mounds near the sow end of the pig. This is no doubt due to compression of the liquid in the interior due to contraction of the outer solidified portion. This phenomenon is only noticed in the forge variety of pig. It is also often noticed that the holes in the upper part of the pig often contain shot and buttons of metal and in low phosphorus pig iron these are usually similar in analysis to the pig iron itself."

A Review of P. Munnoch's Research Work.

The above description, analysis, etc., of Mr. Munnoch's researches are exceedingly valuable. The writer offers the following comments on causes and remedies for the defects cited. The first item he would call attention to is Mr. Munnoch's statement of "some castings weighing about ten tons, with thicknesses varying considerably, and the molds were largely built up of cores, some of which were difficult to vent satisfactorily." If I were asked what was the cause of the buttons, shot, gas cavities or blow holes in the castings cited by Mr. Munnoch I would, to make a brief reply, say: THE MOLDS. The character of the metal used had practically nothing to do with their creation. In other words, could the molds forming these castings have been poured with right temperature metal, through well-constructed skimming gates, without the occurrence of a flurry, bubble or boil, as the mold was filling up, or afterwards in the metal solidifying and being brought to a solid state by proper feeding, I venture to say that all the castings he cites could have been cut up into 1-inch cubes and not a single gas cavity or button of metal would have been found in any one of the thousands of cubes that would have thus been formed.

Blowing Molds Creating Shot and Buttons.

Mr. Munnoch shows that he obtained some very large specimens of shot or buttons, such as a bubbling or blowing mold

could easily create. To obtain some practical ideas on this point requires one to watch the action of but a few blowing molds. A bad blowing mold can often throw much of its metal three or more feet high, if risers and feeding heads were blown or left open to allow the boiling metal free play to kick and jump as the explosive force of encased steam and gases could compel it to do. In metal being blown up it must come down. In doing the latter it is easy to discern how very large globules or buttons can be formed by small bodies of metal lodging on flat planes, projecting bodies, flanges, etc., of a mold. Or again to fall back directly into thick or thin baths of dull rising metal. These buttons or shot having been oxidized or covered more or less with a dross collectible in their upperward and downward flight, would naturally create some gas cavities when liquid metal surrounds them.

Another point that should not be lost sight of is the great chances there are for the creation of blow holes entirely free of either buttons or shot in castings in which the metal had bubbled or "blowed" when they were being poured and cooled to a solid state.

Two Causes for Creating Gas Cavities Possessing Shot.

A close study of the gas cavities cited by Mr. Munnoch shows that there were two kinds. Some of these were formed by the gas created from an embedded button or shot. Others by the sole effect of gases or steam created by a mold or its cores endeavoring to escape from imprisonment, but being caught formed cavities into which were forced particles of the surrounding metal to form buttons, or shot that might hang to their roofs, or be loose in the cavities. A perplexing part of Mr. Munnoch's discovery lies in the difference of the chemical constituents of two buttons that he cites as having been found in the same cavity. There is much embodied in Mr. Munnoch's commendable researches that will no doubt incite further study and investigation contingent to this subject, aside from what can be charged to the direct responsibility of the molder and his overseer.

Buttons, Shot and Gas Cavities Created by Methods of Gating.

The writer's receipt of letters and samples brought some replies that while not strictly in the line sought for, bordered upon them so closely they are valuable enough to be considered herewith. One special case having a very close bearing on others of a similar character is that of a foundry foreman in California having a large retort casting rejected on account of the existence of many cavities and large buttons of metal mixed with masses of dross in a certain location of the cope section of his casting. The sample forwarded is seen at Fig. 4. Upon corresponding for particulars I came to the conclusion that the defects were wholly due to the method of gating used. The mold was of green sand and the metal rushing into it cut against some green sand fronting the gate for fully thirty seconds or more before it reached a level of the gate, so as to have metal in front of it to retard its cutting action. The inflow of the metal at the gate would on directly striking the bare face of the mold splatter in all four directions. The separated particles would fall back in partly solidified small bodies to often lodge on the top of dross created by the cutting action of the mold's inlet gate. As the metal rose slowly in the mold it lifted the accumulated bodies of mixed dross and solidified buttons of metal carrying it all upward until striking a horizontal plane that imprisoned it to await a complete filling of the mold and solidification of the metal in it.

Blow Holes Produced by the Use of "Dull" Metal.

An experienced molder and foundry superintendent in writing from New York State says: "The writer cannot furnish any specimens just at present, but I had a little experience at one time that always comes in mind very vividly and causes me to sit up and take notice when any one talks 'shot iron' or 'blow holes.'

"A few days after taking charge of a new foundry in this State I was introduced by a mutual friend to a machine shop proprietor as a man who would cause all his troubles to end with castings as soon as I commenced to make them for him. I at

once received an order for ten sets of milling machines, the V-slides of which required to be perfectly free of blow holes, and clean when finished. The castings were made and were all cleaned up to look A No. 1. In about ten days after their delivery a drayman hunted me up to say he had a big load of defective castings. I found the same to be the ten nice milling machine beds I had made for the man to whom I had been introduced as a person who would put an end to his receiving bad castings. Every one of the castings had been on the planer, and all showed 'shot iron' in the top and cope V's. It was the biggest bunch of bad castings I ever got back at one time or since. I had been handling this particular job quite a distance from the cupola, and had to change the ladle from one crane to another in order to pour the molds. Before starting to replace the bad castings I figured out that the 'shot' was formed by the air in the mold, and while the metal was traveling over the body of the cores also that the shots were carried up into the top V's and the metal was not 'hot' enough to remelt the shot. I put the job where I could swing a ladle right from the cupola to quickly pour the castings, and never lost another one because of 'shot iron' in them."

Creation and Effects of Oxides and Gases in Iron.

The contention of the writer herein for molds being more responsible as a general thing than the iron for the creation of blow holes, etc., is not to be taken as meaning that there is nothing to be feared by gases that may emanate directly from some irons. We have, of course, as is shown by Mr. Munnoch's recital of oxidizing conditions during melting, an evil that is to be combated, but the writer contends that this is a feature for which the overseer or shop manager is often largely responsible and can as readily be guarded against as can evils in molding. A metal that is dangerously loaded with an oxide of iron is readily observable to the practiced eye of an experienced foreman or shop manager, and only the roughest of castings should be poured with it, if such metal had to be used.

Light work suffers, as a rule, from the oxidizing conditions of melting and handling metal more than heavy work, causing light work founders to often have much trouble with hard spots,

hard streaks and pin holes in their casting, shot iron in gas cavities being little in evidence with them.

The action of oxides of iron in liquid metal is a good deal like that of excessive sulphur, it reduces fluidity, causing metal to be sluggish and scummy. Melting iron "dull" oxidizes it more than melting it "hot." The higher temperature protects the metal better from being oxidized by reason of its dropping more quickly from the cupola's melting point through the fuel to its bottom bath and also by reason of the manganese and silicon in a mixture being brought to a higher fluidity to thereby the better assist the creation of a fluid slag for floating over a metal surface in a cupola's bottom to the more annul the direct oxidizing effect of the blast.

Any one giving much study to the various defects treated by this paper cannot but be greatly impressed with the importance of melting iron so it will come down as "hot" and fluid as practical, as an agent to help prevent many of the defects cited herein. It is to be remembered that if metal is too "hot" to pour a mold it is much easier to cool it than to make any endeavor to increase its fluidity by reason of adding alloys or compounds to metal when in its ladle.

Alloys Used for Deoxidizing and Purifying Iron.

Quite a large number of alloys are now manufactured for the purpose of eliminating the natural and acquired impurities in iron, some of which may cause the defects treated in this paper, especially for light work. A large portion of these alloys are composed chiefly of manganese, and with the exception of where they are intended to strengthen iron, or give it some peculiar character, they can achieve little or no more than manganese used solely by itself.

We also have aside from manganese as currently known, silicon and phosphorus, all of which are obtainable in a ferro form with other constituents. The manganese ferro being as high as 80 per cent., the silicon 50 per cent. and the phosphorus 20 per cent., and each obtainable in a lump, pea or ground form. These ferros are best used by being placed on the bottom of a ladle and having the metal tapped onto it, to be sometimes assisted in their work by the metal being agitated with a green

stick or rod of iron. The amount of these ferros to be used will depend on the character of pig and scrap melted in connection with that required in the casting. The three ferros can be used from having ¼ pound to 1 pound of either per hundred weight of metal in the ladle. The phosphorus serves as a scavenger when used to purify metal, by reason of its increasing the fluidity of the metal to thereby permit sulphur, oxides or occulated gases a better chance to escape. In connection with the above we have aluminum that can be placed on the bottom of a ladle to the extent of ¼ pound to 1 pound per hundred weight of metal in it. Aluminum is obtained from being all pure down to 85 per cent. of it in alloy with other constituents. Ferro-manganese and silicon are also used in the cupola along with lime or other fluxes to help deoxidize and desulphurize mixtures of iron. The above current general known points of this paragraph are given here to make this paper more complete.

"Inside Chill" or White Iron Inside of Gray or Soft Iron.

We have now come to a phenomenon that exceeds most any that might be mentioned in foundry practice, for being of a character that so far has not been satisfactorily explained, at least not to the writer's knowledge. The solution is one that presents conditions that are evidently as unreasonable to exist and be explained, as if one would in hitching a horse to a wagon find the wagon pulling the horse and then endeavor to demonstrate the cause.

The occurrence of "inside chill," so called by Mr. Walter H. Wiard, chemist of a large foundry firm in Illinois, who wrote me on this subject, is so seldom as to be never seen in a life's experience of a great many foundrymen. Nevertheless it is important that we should know the cause of this defect if such information can be obtained. An extract of the long letter sent me by Mr. Wiard states:

"As I have met with an excellent example of this peculiarity of cast iron, I take pleasure in submitting to you all of the data I have at hand.

"This phenomenon has occurred only once in the last nine months to my knowledge, and I am told it is the second time it has happened within the last two years.

"Only two kinds of castings were complained of out of a probable heat of eighteen tons of castings of a similar nature.

"I am enclosing a rough sketch of the castings. The inside chill extended throughout the entire casting, and the demarcation from the soft iron was very sharp and distinct." Following the above, Mr. Wiard's letter gives a very complete description of iron mixtures and methods of melting, etc., but believing this can offer no basis to account for this unreasonable phenomenon shown by Figs. 5 and 6, made from sketches forwarded me, I have thought it best not to take space to print the same.

Explanation for the "inside chill" has been published, but as far as I can remember did not receive my approval and led me to believe that some experimenting to actually produce such results at will were necessary before any one could feel satisfied with a solution of this problem. This the writer hopes to take up in the near future, and as an aid to this end he kindly solicits the experience and views of any that might think they could throw any light on this subject, as well as any of the other points treated by this paper.

Any one having sent samples to the writer and not seeing mention of them in this paper will, it is believed, find the treatment given others here serve to tender them information on their special cases.

The writer desires it understood that he will continue to welcome the receipt of any and all defective samples in the line solicited in the first part of this paper that can be sent to him before next September. He is desirous of receiving as many different samples as he can, as by having a variety created under different conditions there is much better opportunity to arrive at definite conclusions as to causes and remedies. Any one sending defective samples are reminded to send all particulars in detail as requested, as by such, much correspondence can be saved and conclusions more quickly attained.

The trade paper and foundry journal of this and foreign countries have been of great assistance in aiding to obtain the defective samples that were solicited by their kindness in publishing the request, and the writer desires to here tender them thanks for the same. Also to all those sending him defective samples and the information requested.

DISCUSSION ON MR. G. R. BRANDON'S PAPER ON MECHANICAL CHARGING OF THE CUPOLA.

DR. MOLDENKE.—I have appreciated Mr. Brandon's most excellent paper on the mechanical charging of the cupola highly, and can find only one flaw in the matter presented, and that is in the underlying principle of evenly distributed charges. There is probably only one position for all of the methods shown in the paper at which a charge will be dumped into the cupola and spread evenly. This position, which all of us who have had to do with mechanical charging of cupolas will recognize to be several feet below the charging door, is often coupled with a special building up of the charge in the car. That is the pig iron, scrap and coke must be so divided and placed, that when shot into the cupola, it will spread the several components of the charge evenly. This I have seldom seen accomplished properly, for the simple reason that we cannot employ George Washingtons on the cupola platform.

In my own practice I have developed a method in which I charge a bucket in the yard—where it can be done carefully and properly with ordinary labor, there being no heat and the bucket right under view—this bucket, and a series of them in turn, being hoisted and swung or run right into the cupola, and the bottom dropped. Fine, even layers are thus obtained. The method is now being installed in one of the big modern foundries, after having been tried out on a 50-ton scale for a series of weeks at another plant of the same corporation.

MR. BRANDON.—I quite agree with the doctor that it is important to have charges level and of uniform thickness to get the best results. This result is obtained by careful operation of the charging machine described in the paper. The operator must be trained and perform his duties intelligently. The same degree of ability, it seems to me, must be necessary in making up the charges in the cylindrical buckets which Dr. Moldenke mentions.

CUPOLA MELTING PRACTICE.

By P. Munnoch.

There is no intention in this paper to touch on all the various phases of cupola practice or cupola equipment. Some of these will be lightly dealt with and a few points will be more fully considered. It has been suggested that some ideas of British practice would be of interest. Owing to the varied conditions under which the British foundrymen labor, it is difficult to generalize.

As regards the cupola in some of the smaller foundries, there are a few of the old relics bequeathed by a past generation. There are others which vary in construction, right up to the best examples of modern engineering practice. Size varies, and internal diameters, when lined, may run up to sixty inches or seventy-two inches in the foundry. In the steelworks there seems to be no limit to size and melting capacity, as some are capable of turning out as much or more metal than an average blast furnace.

As regards duration of blow, the steelworks have no difficulty in running the cupola continuously throughout the week. At many foundries we find the cupola melting iron from starting time in the morning until stopping time at night. In some cases, blast is stopped at meal hours; in other cases the cupolas run through without a stop. There are foundries where the cupola runs for two or three hours during the morning and is then blown down and allowed to drain. In the afternoon coke is added to replenish the bed and the furnace filled up and run for two or three hours during the afternoon.

These methods are in use where large quantities of castings are required of one type, or for which similar metal may be used. Where several mixings are melted in the same cupola, they are usually separated in the ordinary manner, by addition of a blank charge of coke.

Continuous melting is usually employed in foundries where floor space is limited and large outputs are obtained either by casting the work at frequent intervals during the day or in other cases by continuous molding and pouring.

Charging appliances are in use at the steelworks where cupola melting is practiced, but this method has not met with extended use in the foundry. The crane and box type of charging is chiefly used in steelworks, but the tipping wagon and side chute is the more usual type used in the foundry. The advantage of mechanical charging over hand charging is most apparent with large cupolas and continuous melting, and some discussion as to the advantage and disadvantage of the various types of mechanical charging apparatus would be welcome.

Blowers of the positive type predominate; fans, however, are used to some extent. Seeing that the turbine blower is being used for blast furnace work, it will, no doubt, be made in suitable type and size for foundry work, if not already in use. Blast pressures vary considerably, but probably average between twelve and sixteen ounces.

The weighing of all materials of the charge is rigidly observed in some cases, in others there is partial weighing and in still other cases materials are not weighed at all. In the latter case, pig is charged by the number of pieces, scrap by the number of shovelfuls and coke usually measured in baskets or riddles. Generally, coke is measured rather than weighed out for the separate charges. The charges are usually small and uniform in weight throughout the melt, but there are exceptions to this.

In the iron making districts, pig constitutes a large proportion of the charge and, contrary to the ideas of some foundrymen, severe tests are met using pig iron alone. In some of these districts the bulk of the miscellaneous scrap is used up in the basic open hearth furnaces for production of steel. In districts removed from the blast furnaces, scrap is used to a much greater extent in the cupola.

Where metal is taken for small castings, bull ladles are often used and the iron allowed to flow continuously, only stopping up the tap hole when absolutely necessary. Various kinds of tipping and tilting spouts are used, also double tilting spouts to fill two

ladles alternately from one cupola. Receivers or forehearths are used with some types of cupolas but these are not extensively used.

Coke is the fuel used in the cupola, and beehive oven coke is most widely used. By-product oven coke is used, but owing to an ample supply of good quality beehive coke, it has not taken its place to any great extent. Average foundry coke seldom contains above 8 per cent. ash and 0.8 per cent. sulphur, and the physical condition is good and regular.

Flux used is chiefly limestone, fluor spar being used in some cases as an addition. The quantity of flux used varies considerably. Some regulate it by the amount of coke used, but generally a certain number of pounds are added per ton of metal charged, the general practice being to use it too sparingly.

Oxidation during melting.—There are two effects which result from oxidation, one of which is the reduction in the amount of silicon and manganese during melting, and the other is the oxidation of the iron. More or less oxidation of iron always takes place but the resulting metal is usually more or less free from oxide of iron and its effects. Often materials in the charge as steel, oxidized scrap, or even pig irons, receive the blame of causing the effects which are due to oxidation. In other cases or under other conditions good clean metal, free from these defects, is obtained from the same materials. It, therefore, appears to depend largely upon conditions of melting. Dr. Moldenke has pointed out that the method of using large charges in the cupola is the chief cause of this trouble, and by reducing the size of the charges and therefore preventing any great variation in the height of the coke bed above the tuyeres, this oxidation is prevented. The term large or small charge is rather indefinite; therefore, it is desirable to have some standard for comparison. It might be defined in pounds of iron per square foot of cross sectional area of the cupola, measured inside the lining. A charge of below two hundred pounds per square foot of cross sectional area might be considered a small or suitable charge and above this amount a large charge. As it is the coke which requires consideration there would still be some difference due to high or low melting ratios; also in the case of dense heavy cokes as compared with light porous cokes. Therefore, the lower the melting

ratio and the lower the density of the coke, the smaller the charge desirable. Therefore, in some cases, one hundred pounds per square foot sectional area might be ample.

The coke ratio in melting varies considerably and results are often difficult to compare as in some cases the coke used for the bed is included and in other cases left out of the calculation.

Total coke ratio. This is obtained from total iron melted compared with total coke used; this is necessary when figuring costs. Coke melting ratio is obtained by comparing the average amount of iron per charge with the average amount of coke per charge. This is most useful for comparing results under varying conditions, as it is not affected by coke used for bed. Coke melting ratio varies from about seven to one to fourteen to one with ten to one as an average figure.

The rate of melting varies considerably, due partly to differences in tuyere area, blast pressure, also to nature of materials of charge, whether dense or open, also upon coke melting ratio. Convenient method of comparing is to take coke burned per unit of time or iron melted per unit of time. In the blast furnace about three and one-half pounds of coke per square foot of hearth area per minute is considered an average figure, but only about two and one-half pounds of this reaches the hearth and is burnt by the blast. For cupolas about two and one-half pounds per minute per square foot of cross sectional area is a good rate of working, results being often considerably less. Area of cross section multiplied by two and one-half and the result multiplied by sixty (minutes) gives ideal coke consumption per hour. This multiplied by ten gives ideal rate of melting in pounds of iron per hour, or multiplied by actual coke melting ratio, gives rate of melting which might be expected under good conditions. These figures are useful to compare with actual melting rate.

Changes occurring during melting.—Some of these are of a more or less stereotyped kind such as the decrease by about .25 per cent. of silicon and reduction of manganese by about one-fourth of the amount present, whether this is 2.0 per cent. or only 0.2 per cent. Whilst these apply in a general way, still, in particular instances we find that conditions have considerable influence; this is especially noticeable with sulphur. When melting all pig charges containing 1.2 to 1.4 per cent. of manganese a

decrease in the amount of sulphur of about .02 to .04 per cent. was usually noted. Melting pig and scrap mixtures containing about the same amount of manganese usually resulted in an increase of .02 to .04 per cent. of sulphur. The scrap consisted of gates and runners from small castings and constituted about 50 per cent. of the charge.

Borings, when added loose or in wooden boxes, usually resulted in increased absorption of sulphur. In some experiments using about 14 per cent. of loose borings in the charge, the increase in sulphur was about .06 per cent. although about

Diameter inside lining, ft. ins.	Area in sq. ft.	Coke.		Iron. Melted at 10–1 ratio.		Charge of iron at 200 lbs., lbs. per sq. ft. area.
		At 2½ lbs. per sq. ft. per minute.	150 lbs. per sq. ft. per hour.	Lbs. per hour.	Long tons per hour.	
2—0	3.14	7.85	471	4,710	2.10	628
2—6	4.90	12.25	735	7,350	3.28	980
3—0	7.07	17.67	1.060	10,600	4.73	1,414
3—6	9.62	24.05	1.443	14,430	6.44	1,924
4—0	12.56	31.30	1.878	18,780	8.38	2,512
4—6	15.90	39.75	2.385	23,850	10.64	3,180
5—0	19.63	49.07	2.944	29,440	13.14	3,926
5—6	23.75	59.37	3.562	35,620	15.90	4,750
6—0	28.27	70.67	4.240	42,400	18.92	5,654
6—6	33.18	82.95	4.977	49,770	22.21	6,636
7—0	38.48	96.20	5.772	57,720	25.76	7,690
7—6	44.17	110.42	6.625	66,250	29.57	8,834
8—0	50.26	125.65	7.539	75,390	33.65	10,052

1 per cent. of manganese was present. An experiment was tried melting borings alone by charging small amounts to the cupola after blowing down, the resulting metal contained about 0.3 per cent. of sulphur although borings only contained .06 per cent.

In melting good clean steel scrap with iron, the amount of sulphur taken up was much the same as when the charge was all cast iron. The amount of sulphur in the coke has a great influence on the resulting sulphur content of the melted iron. At a foundry where low sulphur iron was a necessity, an attempt was made to use coke containing 4.0 per cent. of sulphur which had been bought cheap in place of the ordinary coke employed which ran about 0.4 per cent. sulphur. In some cases it was used in

the bed alone; in others, was mixed with good coke, and for a short time was used alone. The sulphur increased in the iron from the usual .06 per cent. to as high as 0.2 and 0.3 per cent. and small castings required soft and gray, were hard and white.

In melting steel and iron mixtures the resulting metal usually contains more carbon than the mixture used. This, of course, is due to the steel absorbing carbon while passing through the cupola. When melting steel alone the result is usually a cast iron containing about 2 per cent. or more of carbon, which makes it impossible to melt steel in the cupola and obtain from it a steel suitable for the uses to which ordinary steel is put.

Although limestone is the usual flux for the cupola, other materials are sometimes used. A founder complained to the blast furnace people, who supplied him with pig iron, that the iron was giving bad results. On investigation, it was found that he was using blast furnace slag as a flux instead of limestone. The slag contained about 2 per cent. of sulphur. As the castings made from the iron were small, there was sufficient sulphur taken up to change the castings from gray to white.

Low sulphur materials are a necessity when low sulphur castings are required, but there are cases where some increase in sulphur is not objectionable and then a higher content of sulphur may be permitted in metal or coke.

When iron is melted in the cupola without the addition of a flux, the slags formed are chiefly silicates of iron, manganese and alumina. On addition of lime, silicate of lime is formed and the slag becomes more refractory as the lime increases, due to some extent to the lime replacing the more fusible iron and manganese oxides. The object of adding lime may be either to flux away the excess of silicious matter, such as coke ash, sand from iron and particles of silicious matter from the lining, so as to prevent accumulation which would interfere with the regular melting of the iron. Or the object may be to do this and also to purify the iron and to prevent absorption of injurious constitutents. The usual loss of silicon and manganese cannot be classed as purification, as the reduction in amount is not always desired or necessary. Removal of sulphur may, in most cases, be called purification, but in other cases it may be necessary to retain or

even increase the sulphur. Removal of oxides and prevention of increase of oxides are the only actions which are always desired.

Removal of the sulphur.—Using coke containing about 1 per cent. of sulphur and melting with a ratio of 10 to 1, there is sufficient sulphur present to increase the sulphur content of the iron by .10 per cent. or to raise the sulphur content of the slag to 1.5 or 2.0 per cent. Ordinary cupola slag, however, seldom contains more than .10 or .20 per cent. of sulphur. This is due to the slags being silicious or acid in character. Large additions of lime would make the slag capable of taking up more sulphur, but the slags would rapidly attack the silicious lining and would be too refractory for ordinary cupola operations. Increase of lime, to some extent, prevents increase of sulphur in the iron, and this must be due to the higher temperature necessary to melt the slag, being more favorable to removal of sulphur by oxidation. Manganese in the iron or manganese oxide in the slag, probably remove sulphur into the slag as manganese sulphide, and sulphur is then oxidized to sulphur dioxide which escapes in the form of gas.

Action of slags in regard to oxide in metal.—In the blast furnace the amount of oxide of iron in the slag practically depends on the temperature in the hearth of the furnace. The composition of the slag appears to have no influence. The metal, with exception of white iron or silicious iron, usually shows no signs of oxidation.

In most of the steel-making processes the metal at some time during the process is in a highly oxidized condition, and steel free from the effects of oxidation is obtained, either by controlling the composition of the slag, by addition of deoxidizing materials, or by both.

In the cupola, composition of the slag does not appear to have much effect, but it is reasonable to suppose that iron melted and held in contact with slags rich in oxide of iron will become oxidized to some extent. As the use of lime decreases the amount of oxide of iron in the slag, this must be more favorable to the production of metal free from oxides. In such a case the slag itself will, under suitable conditions, remove oxide to some extent from oxidized iron. The use of limestone is, therefore, advantageous in cupola melting.

Limestone requirements of cupola charge.—There is no necessity to make any elaborate calculation of chemical compounds, as a cupola slag, like a blast furnace slag, cannot be made to accommodate itself to theoretical ideals.

Slags are usually controlled by following certain types of slag with a more or less flexible ratio of acid to base, or more generally, silica to lime or to lime and magnesia. In the cupola, slags seldom contain more than one part of lime to two parts of silica. This may, therefore, be adopted as a suitable basis for calculation. Using coke with about 10 per cent. of ash, one-half of which is silica, and a melting ratio of ten to one, gives about ten pounds of silica per 2,000 pounds of iron. Sand cast pig may carry from five to thirty pounds of sand per 2,000 pounds of pig, according to time in stock and amount of handling it has received.

Shop scrap, such as gates, runners, etc., may carry a great deal of sand, probably from thirty to sixty pounds or more per 2,000 pounds. Sand may be taken to be all silica for purpose of calculation. Silica from the silicon oxidized from 2,000 pounds of iron, is about ten pounds. Silica from the furnace lining is variable and difficult to estimate, as it varies according to temperature and composition of the slag. A rough idea may be obtained from the amount of ganister used. As all figures are based on mere estimates, a rough calculation is all that is necessary. A few experiments using a pickling solution, or otherwise removing sand, would be useful for this purpose. Limestone will probably contain about 50 per cent., or slightly above, of available lime. Therefore, equal weights of limestone to silica in the components of the charge used will give suitable amount to add, after making allowance for silica from lining.

Generally the amount required will vary between thirty and sixty pounds per 2,000 pounds of iron.

TITANIUM IN STEEL.

By Charles V. Slocum, Pittsburgh, Pa.

In steel castings the same principles may be said to hold good as outlined in the paper on titanium in iron for the American Foundrymen's Association, viz: In order to secure increased fluidity and ductility of the steel, the small percentages of alloy such as one or two-tenths of a per cent. have been used successfully by a number of manufacturers and for a further increase of ductility, density and greatly increased strength, the larger percentages from three-fourths up to one and a half or even two per cent. are extensively used.

It must be remembered that the smaller proportions are not sufficient to give the full benefit of which titanium is capable, any more than a small dose of medicine is capable of doing what a more powerful one might be expected to accomplish. When we make a decided effort to improve any material it is always necessary that some good judgment be used in connection with it. For instance, what good would it do to add a certain percentage of manganese to the slag? And yet the writer has several times seen the usual deoxidizers added so late that a further deoxidation by the use of titanium was wholly impracticable.

When the attempt is made to purify steel by any method whatever, several requisites are necessary and mention is made of some of them here for the sake of a more general understanding of what we are trying to explain in this paper. In the first place practically all steel makers endeavor to fully deoxide their steel by using more or less of the well-known deoxidizers manganese and silicon. These two factors are known in every mill of any merit the country over. The melters try to remove other shortcomings with these elements also. For instance, the metal is sometimes over melted and then the melter tries to bring the steel back to normal conditions by putting in more manganese or more silicon or both perhaps, occasionally making the steel too high in these elements to pass the specifications or too full of blow holes to pass the shop inspection. Sometimes one of these

same heats thus spoiled is one in which titanium is later added and the failure is charged to the latter, *i. e.*, to the element which could have saved the heat had it been used in sufficiently large proportions of say one per cent. or more and in sufficient time.

One great advantage in the regular use of titanium alloy is that it removes those features of irregularity which have given steel a bad name for its unreliability in a number of directions. It would be out of the question to secure as uneven or irregular results in any mill when using titanium regularly as is frequently known to be the case without it. Heat after heat has been made with the addition of titanium in regular practice and when the chemical analysis of the mix has been practically uniform, the results have been equally good.

So many manufacturers have now used titanium with success as a cleanser of steel and iron that it is needless to speak of this point further beyond merely stating that it is useless to experiment with any material whatever under anything except normal conditions, for otherwise the results become abnormal and perhaps may never be duplicated even if desired.

In a recent trial of the alloy in basic open hearth by one of the large steel makers, it was found that in order to remove the last vestige of brittleness and of blow holes, the use of one and one-half per cent. of the alloy was necessary. This in turn made the steel so dense that it was unusually strong and became the source of much comment and investigation by all concerned. It is not possible to remove all of the causes of poor castings by the addition of titanium nor with any alloy whatever. Good foundry practice is more necessary in steel than in iron because more harm is likely to result if the castings are not as good as they should be. When the mold is not properly made or baked; when the mix is not properly figured and prepared; when the melt is not looked after to prevent over heating, etc., it all comes back to the original statement that other things are necessary as well as the use of alloys, for good steel making.

When we learn that in some mills a sinking head is cast which weighs considerably more than the casting itself and the latter in some instances weighs eight tons, then we see at once that foundry practice has given way to the sink head and it is a wonder the casting itself does not give way as well.

Compare the cost of a nine ton sinking head to make an eight ton casting, with the cost of titanium alloy in sufficient quantity to remove the blow holes which the big sinking head removes and it figures out about as follows with castings at three and one-half cents per pound and scrap at three-fourths cents per pound:

9 ton head 2,000 x 9 x .035 ....=	$630.00		
Less scrap value 2,000 x 9 x .0075 ....=	135.00		
			$495.00
Maximum head of say 40 per cent. by using Ti 2,000 x 8 x .40 x .035 ....=		$224.00	
Cost of 1.00 per cent. titanium alloy for 8 ton casting and 40 per cent. head 22,400 x 1.00 @ 12½ ....=		28.00	
		$252.00	252.00
Difference in favor of titanium			$243.00

When we take into consideration the fact that so small a proportion as one-tenth of one per cent. of titanium alloy makes a noticeable improvement to steel as vouched for by some of the largest steel makers in this country and that larger proportions up to say two per cent. add materially to the improvement, then it becomes clear that the small cost involved which runs from 25 cents as the minimum up to $5.60 per gross ton of product as the probable maximum, is something which every steel mill may well take into consideration and begin to save money by reducing their percentages of bad work.

The following proportions have been used regularly in a well-known steel mill where only the best results are accepted and where the product is said to be equal if not superior to the best stamping steels made in this country:

BASIC OPEN HEARTH STEEL.

Size of heat, 120,000 lbs.

	C.	Mn.	P.	S.
Analysis	.10	.33	.007	.019

Titanium alloy added in ladle, 250 lbs. = 0.21 per cent., or 0.021 Ti.

Aluminum added, 10 lbs. = .01 per cent.

Elastic limit, 37,060 lbs. per sq. in.
Tensile strength, 44,920 lbs. per sq. in. } after dead soft anneal.

Elongation in 2", 40 per cent.

Elongation in 4", 28 per cent.

Reduction of area, 56.4 per cent.

Fracture, silky.

In the mills of one of the most scientific steel makers in the United States, steel castings are required of the following specifications:

Elastic limit	45,000 lbs. per sq. in.
Tensile strength	85,000 lbs. per sq. in.
Elongation after rupture	12 per cent.
Contraction of area	18 per cent.

"These specifications have been met and the necessity for numerous heat treatments have been avoided by the use of eight pounds of titanium alloy per ton of metal (= 0.4 of alloy or 0.04 Ti) added in ladle. No aluminum was used."

These parties write as follows:

"Comparing the results of the tests made upon specimens after the first anneal, of the last fifteen heats in which ferro-titanium was used, with those of the last fifteen previous heats in which it was not used, it appears that the mean tensile strength was increased from 81,633 pounds per square inch to 91,533 pounds per square inch, that the mean elastic limit was increased from 47,233 pounds per square inch to 50,000 pounds per square inch, that the mean elongation was increased from 15.1 per cent. to 19.2 per cent. and that the mean contraction of area was increased from 18.9 per cent. to 24.3 per cent."

In a letter dated April 12, 1911, Mr. J. H. F. Dixon, General Manager of the Keystone Steel Casting Company of Chester, Pa., makes the following comment on the use of titanium alloy in their steel castings:

"The added cost of the production of our metal by the use of this alloy is so slight that we are prepared to furnish genuine crucible castings titanium treated, at the same schedule of prices which apply to our carbon steel. We strongly recommend," he states, "the use of steel so treated for automobile work, where the castings are subject to unusual shocks and where uniformity of the material is absolutely essential."

In a letter dated April 8, 1911, Prof. Enrique Touceda, of the Rensselaer Polytechnic Institute writes as follows:

"The beneficent results of the (titanium) addition can best be illustrated as follows: It is difficult to make a good weld with plain steel because on heating the two parts to be welded the

surface of the metal oxidizes and this oxide prevents the two metallic parts from coming in close contact when being hammered for welding.

"In the case of steel if sand or borax or some similarly acid material be sprinkled on the parts to be welded, the silica of the sand will unite with the iron oxide forming silicate of iron. This silicate of iron, unlike the iron oxide, melts at a low temperature, is not viscous and when the two pieces of steel are struck for welding, the fluid slag of the iron silicate is forced out and the two clean surfaces are brought intimately together and a good weld results.

"Let us now consider the two surfaces referred to as if they were the sides of two large crystals, in order to draw the analogy.

"All steel is composed of an aggregation of crystalline masses, each crystal having a definite boundary, and each crystal being welded, so to speak, with or into its adjacent ones. It is a well-known fact that the impurities in all metals and alloys tend to segregate at the boundaries, which fact well explains the damage done by certain additions, such as bismuth to copper, etc. The beneficent action of titanium is due to the fact that it makes more intimate the contact between the crystals in the steel, thereby making the cohesion more perfect. It is known that the occluded gases segregate to the boundary of the crystals also, and the uniting of the titanium with the occluded nitrogen makes more perfect the union of the crystals to each other.

"It is manifest, therefore, that the improvement will not be fully shown in the usual tension tests, as these tests have to do with stresses that are equally applied in the same direction, and such tests do not tend to act on the crystals eccentrically. On the other hand, in the Landgraf-Turner machine, the tendency is for the boundary of the crystal to open up, first on one side, and then on the other, and at one instant the very edge of the united crystals are receiving the entire load so long as distortion continues, while the reverse action takes place when the test bar is hit on the other side. It is in this kind of testing that the worth of the bond between the crystals is shown, and this explains why these tests show better with the titanium treated than with the untreated specimens."

To ascertain more clearly the relative values of the alloys

which are known as the best deoxidizers, it may be interesting to consider what the actual facts are in regard to some of them. For instance:

Titanium, combining with oxygen as TiO_2, we have:

TiO_2 = titanium 48, oxygen 32, so that 1 titanium takes up $\frac{32}{48} = 0.66$ + oxygen.

Similarly, vanadium oxide V_2O_3 contains $\left\{ \begin{array}{l} V_2 = 2 \times 51 = 102 \\ O_3 = 3 \times 16 = \ \ 48 \end{array} \right\}$ so that 1 vanadium takes up $\frac{48}{102} = 0.47$ oxygen, or if you wish to put it so

$\left\{ \begin{array}{l} 1\tfrac{1}{2} \text{ titanium takes up } 1.00 \text{ oxygen.} \\ 1\tfrac{1}{2} \text{ vanadium takes up } 0.705 \text{ oxygen.} \end{array} \right.$

In other words titanium is nearly 30 per cent. more powerful than vanadium and requires far less of it to accomplish the same results.

As a denitrogenizer, if such a word be permissible, the highest authorities, living and dead, have given the verdict that titanium has no equal. Moissan, le Chatellier, St. Claire Deville, Wöhler and others all give testimony to the powerful action of titanium in attacking and removing nitrogen. Specimens of nitrides were rare until titanium came into common use but now may be had for the asking.

In conclusion I may state that all the world now knows of titanium and its recently developed powers for improving both steel and iron, which may be summarized briefly as the most easily used, the most powerful and the least expensive of any alloy above the grade or cost of manganese and silicon.

TITANIUM IN IRON.

By Charles V. Slocum, Pittsburgh, Pa.

When the manufacture of titanium in the shape of an alloy was undertaken on a commercial scale in 1907, the results in primary tests were considered for a time as the basis upon which it would be necessary to place this material on the market. When a number of trials had been made, however, it was found that different results were apparently secured and it then became necessary to modify these original ideas in accordance with these developments and in fact since three years is not a long time to learn everything in regard to a new element, this modification is still on.

When it is remembered that the output of titanium alloy exceeds that of all other alloys combined above the grade of manganese and silicon, and that this development has been made in such an unusually short period, it is safe to assume that as time goes on the results will be still more developed, percentages changed for certain purposes and the whole situation become more definitely systematized and made to conform more readily to the methods and ideas which time and experience can alone develop to the fullest extent.

It was the idea at first in using titanium in iron that since comparatively large percentages gave increased strength in tensile and transverse tests, that these larger percentages were essential to the process of securing a titanium reaction in the metal and therefore must be used. Gradually, however, it became evident that minute percentages of titanium were successful in producing many of the benefits of a larger quantity. As for instance the use of two-tenths of one per cent. of alloy which contains only 0.02 of metallic titanium is frequently sufficient for the purpose desired, which consists principally of cleaning the iron of impurities remaining in the metal after the ordinary fluxes have accomplished all that they can in this direction. This cleansing is not one which is possible with limestone or with fluor-spar, for these

fluxes have no effect whatever upon the oxides or nitrides contained in the molten iron.

Titanium, on the other hand, removes both of these objectionable elements partially in any event and wholly or practically so when sufficient alloy is used for the purpose. The effect then of the small fractions of a per cent. in iron is, more practically speaking, to increase the fluidity of the iron and at the same time to make the metal more homogeneous, so that the resulting castings are closer grained, are free from pin holes and gas bubbles or blow holes, the iron has a denser structure and at the same time is easily machined.

The shrinkage is less in the treated iron than in the plain or untreated casting. This is particularly true in hard or chilled iron, where heavy castings, such as car wheels, will shrink an eighth of an inch less or one whole tape number in circumference.

Much finer work may therefore be done with iron treated with the alloy, since the casting will conform more nearly to the original pattern and will have a more uniform shrinkage than the plain iron.

In a letter dated April 5, 1911, the writer was advised by Mr. Asa W. Whitney, metallurgist of the Enterprise Foundry and Machine Co. of Bristol, Virginia, that he has made a number of careful trials of titanium in hard or chilling iron. He finds that 0.1 to 0.2 per cent. of the alloy is usually all that is necessary to make otherwise viscous, high chilling mixtures come from the cupola close grained and pour from the ladle as freely as iron carrying half as much chill and of more open grade. The iron pours well to the last and gives clean solid castings. "I find," Mr. Whitney says, "that I am able to compensate for the cost of the titanium with less manganese and a trifle less silicon."

To foundrymen the fact that the metal remains hot longer than untreated iron is a matter of much importance for certain classes of work, since the greater fluidity means that the iron will settle more slowly in the mold, and thus give time for the gases to escape and more time for the iron to fill every smallest outline of the mold without pulling away from the main body of the casting. These features of good foundry practice are some of the ones which are often overlooked, and a high percentage

of bad work results. Now in relation to the benefits to be expected from using larger proportions of alloy, I maintain that a great deal of undue importance is often attributed to an increase in transverse and tensile strength. This may be necessary for certain government work and for some few castings which must resist unusual stresses in service, and for such it is necessary to use at least one per cent. of titanium alloy.

My contention is, however, that such a percentage is not only a serious increase in cost per ton of product for ordinary castings, but in all the practical uses to which most castings are subjected no special increase of strength is required, although an improvement in quality may be absolutely necessary. We have in mind a recent case where the castings in a certain foundry were stronger than necessary, were well made and were satisfactory to the foundry superintendent and to his customers, but when he tried the small quantity of alloy usually recommended for such cases merely for the purpose of improving the fluidity of the molten metal and the density, machining quality and durability of the casting, he found that the machine shop of one of the great railroad companies which turned up the castings, reported that these treated specimens (piston rings) were closer grained, were more like steel and were more desirable for their purposes. Yet of the four test bars cast, one of untreated iron was strongest in transverse strength.

On the other hand a large manufacturer of my acquaintance having a ten-ton casting to make and being anxious to have no failure in so important a job, added one per cent. of titanium alloy and secured a splendid casting which may have cost him $25 extra for all the alloy used, but which made a sure thing of a single part of the machine worth at least $400 even without including the machine.

To summarize these statements then, it may be said that titanium alloy is of great benefit, in small percentages, for fluidity, for sharper castings, for remarkable uniformity and for durability while the larger percentages are for strength and density of metal in addition.

I realize of course that certain classes of work do not justify an increase of cost to any extent worth mentioning, and yet even in cheap work the use of a pound or two of alloy per 1,000 pounds

of iron is a distinct benefit to the metal and costs but 25 to 50 cents per ton of product. Other classes which will perhaps bear a little more expense may be increasingly benefited with three or more pounds per 1,000.

One important feature of titanium in iron should not be overlooked, viz.: the great durability of all metal into which it enters. In some tests made by Prof. M. Hokanson at the Carnegie Technical Schools some two years ago the following results were obtained:

Chilled test blocks machined down to approximately ½ inch x ½ inch x 1 inch were used.

First Test.

Under crushing strain, blocks from plain untreated iron developed 173,000 pounds per square inch at failure. Metal from same tap of cupola, but treated with one per cent. of titanium alloy, developed 298,000 pounds per square inch at failure.

Second Test.

Chilled test blocks from a different foundry and made from plain iron, machined as were the others previously mentioned, developed 200,000 pounds per square inch crushing strength at failure, while similar pieces from same tap of cupola but treated with one per cent. titanium alloy, developed 392,000 pounds per square inch at failure. It seems to be this quality of burden bearing imparted by titanium which has made such a demand by railroads for its use in steel rails.

Iron castings which require great care in molding and which are difficult at all times to make, may well be treated with titanium, for such castings cost much money to manufacture, and a high percentage of loss works havoc in the showing of profits for a year's business.

In cylinders, for instance, and for locomotive and stationary engine castings of various kinds, many manufacturers from the Atlantic to the Pacific are now using this cleanser and purifier as a means of not only improving the casting itself, but of reducing that deadly percentage of loss which often stares the foundry officials in the face from one month's end to another.

The feature of greater fluidity cannot be emphasized too strongly. When we seek for increased fluidity through the addition of ordinary fluxes the result is often disastrous, for much fluxing makes the metal boil and blow holes, pin holes and defective castings generally result, together with increased expense in the repairs or even in actual relining of the cupola, sometimes necessary from this method of procedure.

When titanium alloy is added in the cupola, it does not affect the lining unless large percentages be used, and when the larger percentages are necessary, it is better to add the alloy in the ladle with the usual precaution of keeping the alloy from the slag so that the full benefit of the use of this cleanser may be secured. There are times when it is not practicable to use the alloy in the ladle and other times when it should be used there.

To illustrate, in adding one per cent. of alloy for purposes already mentioned it should preferably be done in the ladle and, if practicable, in the receiving ladle, but this can only be done there when it is possible to keep the iron free from slag by skimming or by some other means. Titanium attacks slag as a bull dog attacks an enemy, and the former should therefore always be used to cleanse the iron from impurities remaining in the metal after the melting process is completed and never by any chance be allowed to reach the slag already on the surface of the iron or about to be removed from its surface.

These facts are presumably quite fully understood by the best foundrymen, but occasionally it is found that someone continues to try the experiment of throwing the alloy into the ladle after the iron is already there and necessarily secures very indifferent results, if any.

In a recent trial of titanium alloy in the cupola with a mixture of burnt iron, stove plate, etc., in a large foundry in the Pittsburgh district the rather large percentage (for iron) of half of one per cent. of alloy was used together with one-half of one per cent. of ferromanganese of the usual 80 per cent. grade. This trial demonstrated the interesting fact that the poorest mix which can be imagined, perhaps, may be brought to good normal number one iron by this method. The average of all the test bars, of which there were ten, was 3,100 pounds breaking strain and an average deflection of .146 inch.

Under ordinary conditions, with the addition of the manganese only, the strength would scarcely have reached 2,000 pounds per square inch.

The name of the plant where these castings were made will be cheerfully given to any one desiring to make the same kind of an experiment. It should be remembered that burnt iron is usually high in sulphur and the iron in these castings contained .151 and .147 sulphur respectively by two different analyses. Such a remarkable strength from such remarkably poor iron is unobtainable at anything like the small cost by any other process, since the expense of making the metal homogeneous, of excellent wearing quality, etc., was about $1.50 per ton of castings. The iron before treatment could scarcely have been given away for ordinary purposes and was possibly worth $10 per ton. The complete analysis of the treated iron by two separate determinations was as follows:

Silicon.	C. C.	G. C.	Phos.	Sulph.	Mang..
1.30	.70	2.50	.504	.151	71
1.30	.74	2.42	.455	.147	79

Average of 10 test bars, 3,100 lbs.
Minimum, 2,900 lbs. Maximum, 3,265 lbs.

Not to be misunderstood, I desire to repeat in brief that high sulphur iron may be made strong and available for practically all purposes by an expenditure as above of $1.50 or less per ton of metal melted.

In the works of one of the best known foundries in Columbus, O., they use for certain purposes a cheap mixture which analyzes about as follows:

Silicon	1.60
Sulphur	0.11
Phosphorus	0.55
Manganese	0.50

One-fourth of one per cent. of titanium alloy was added in the cupola and the foundry foreman reported immediate benefit in the fluidity of the metal and in the distinct improvement to the castings. This rejuvenation of the iron, so to speak, involved an extra cost of 62½ cents per net ton of metal treated, and was more than repaid in the reduction in bad work without regard to

the benefit to the iron. Castings from this iron, with fine grain and good metal, were made which were only 5/16 inch x 1/4 inch section.

As a substitute for charcoal, iron titanium is making much progress. In a letter dated January 9, 1911, the Secretary of the American Foundrymen's Association, Dr. R. Moldenke, states as follows:

"I am getting more and more confirmation that by the use of titanium as one of the most easily oxidized elements I know of, we will eventually make a common coke iron equally as good for our purposes as the best cold blast charcoal iron of the same composition."

In a letter dated December 3, 1910, Prof. John J. Porter, of the University of Cincinnati, gives expression to the following idea of the merits of titanium as a means of securing better castings without regard to the mere question of strength, which as a rule takes care of itself in a well-regulated foundry:

"I believe most thoroughly in the great value of titanium in cast iron. I know that it will remove many of the causes of bad castings and feel sure that many foundries can save money by using it, in addition to obtaining a better quality of castings. I have several times seen this demonstrated."

Now there are a few suggestions which occur to the writer and which may have become familiar to others, but it will do no harm to repeat them, viz.:

In using any alloy do not govern the quantity or the method entirely by the mere untested statements of others, but be governed largely by the particular features and practices of the foundry in which the trial is to be made. For instance, one of our best known manufacturers reports a failure of titanium alloy to improve iron when used in a cupola which was not slagged and which therefore kept the titanium in almost constant contact with the very impurities which should have been kept away from it. Such a poor use of good gray iron should be placed in the dark corner and kept there for all time.

Another questionable procedure is to have a few of the castings looked after carefully by some good man like the foreman or even the superintendent, and then to have the other titanium additions for the same kind of iron and from which the same

results are expected, looked after by some laborer or "hunkey" with as much knowledge of the necessities of the case as the city directory has of metallurgy.

The don'ts are almost more necessary in the use of this alloy than important rules of guidance. We put an alloy into an iron or into steel for a distinct purpose, but unless we can at the same time place a little common sense and good foundry practice along with it, the results will be doubtful in the extreme. We can undertake to put a great deal of pressure upon the foreman, but unless he has sufficient foresight to realize, for instance, that silicon although used as a softener, is also at times a great weakener of good iron and therefore should be used as sparingly as possible with titanium (which does all the softening necessary without doing any weakening at all), it would be useless to instruct him as to the merits of any alloy. A mere man is only one of the most obtuse of God's creatures unless he uses the good gray matter with which most men are endowed and which is so necessary in the manufacture of good gray iron.

In conclusion the uses of titanium in iron may be summarized as follows:

Very small percentages, as low sometimes as 1/10 of one per cent. (0.1) of alloy (only .01 Ti), are sufficient to cleanse the iron of impurities not touched by limestone or fluor-spar, while larger percentages increase the improvement in other directions, making the iron more fluid (usually hotter), making the castings sharper, finer grained, free from blow holes and pin holes and easily machined, while at the same time the expense runs from 25 cents per ton of castings up to say $3 as a maximum, all of which is often repaid in the reduction of bad work and in improving poor irons.

CUPOLA PRACTICE.

By R. H. Palmer, Salem, Ohio.

My first melting experience was with a MacKenzie cupola in which Anthracite coal was used, and since with different sizes and styles of cupolas using coal, coal and coke, Lackawanna coal, and what we term in New England "gas-house coke." Also with different arrangements of tuyeres.

When starting as a foundry foreman, realizing my need of knowledge regarding the subject, as there were few books and no trade papers to be obtained giving the necessary information, I called on one who in his vicinity was considered a leading foundryman and sought to obtain information regarding cupola practice. He kindly informed me, "Experience would have to be my instructor." And it is from practical experience that I offer you the following.

In the years past, as we have visited foundries and found different styles of cupolas with different arrangements of tuyeres, comparisons of melting ratios were usually in order. But formerly conditions and classes of castings produced were not always taken into consideration as at present. Owing to the attention given with the consequent advance, largely due to the efforts of the founders, members of this Association, the difficulties encountered are better understood, and while high melting ratios are obtained under favorable conditions, such conditions do not always exist.

In taking up cupola practice, let me first refer to the manner of laying the fire brick in the cupola. In too many foundries this is carelessly done. The bricks are laid too far apart and too much buttering in is required, which soon melts or burns out leaving the edges and corners of the bricks exposed to the intense heat, the effect of which is soon seen. The closer and more solidly the bricks can be laid with the least amount of buttering in and grouting, the longer the lining will last. While many prefer a single thickness of lining, I find the double lining more satisfactory in large cupolas. If the clay used to lay the

brick is the same as that of which bricks are made, the better. Poor brick are dear at any price.

Mica schist is used in place of fire brick in some cupolas with good results. The schist in form of broken stone is laid in mortar made of ground schist. Lining above the melting zone with cast iron, cast into bricks and buttered in, is proving satisfactory, I am informed.

All cupola linings should be thoroughly dried out before the cupola is used, as the lining will last much longer.

There are a number of styles of tuyeres in use giving good results, some special advantage for each being claimed by their introducers, those shown at the Toronto Convention being, I believe, a movement in the right direction.

While some prefer one row of tuyeres, and in some cupolas good results are thus obtained, for the larger ones, I believe a majority will agree that speed in melting with greater melting ratios are obtained by the use of two rows of tuyeres. Cupolas are generally arranged with tuyeres based on 30,000 feet of air being required per ton of iron melted. The introduction of a sufficient volume of air at the right pressure through a properly arranged set of tuyeres, which will distribute the air to the fuel in such a manner that perfect combustion may be obtained, is of the utmost importance for successful and economical melting in a cupola. Though the right amount of fuel be charged, if not supplied with air as above, poor results are obtained.

That the lining will not last as long with two rows of tuyeres as with one, has been my experience, especially if too high a blast pressure is used. I am not in favor of small tuyeres and high blast pressure, I prefer larger tuyeres and less pressure. The angle at which the upper tuyeres are set have their effect on the lining and melting point. I will refer to setting the tuyeres later. While discussing tuyeres one is apt to have brought to mind the tub blowers of years ago, and while the fan blower is preferred generally for the smaller cupolas, the modern pressure blower, driven by a variable speed electric motor, so that the speed may be easily adjusted to suit conditions, is very convenient. In connection with advanced blower construction, let us view the electro-magnet unloading the pig iron from cars and dropping it into bins, or upon the charging stage; the air hoist

for raising the heavy bottom doors of large cupolas, and dropping the bottom when the heat is over, thus effecting a saving and avoiding danger.

The turning of the hose into the cupola to cool it off before chipping it out should be avoided, as by so doing the bricks are soon destroyed.

While I wish the cupola properly chipped and cleaned out preparatory to daubing up, I have seen cupolas chipped out to the extent of removing the face of many of the brick. This should be avoided. When daubing up in parts where the lining is thin, build in either split brick or pieces of broken brick. Some melters have a happy faculty of repairing a cupola lining so it will last, and take pride in doing so and having the cupola work well; some, so that it will not last. A trustworthy melter is a valuable man, and should receive his due. The tuyeres and wind box should be kept clean. I have seen many alarms arranged for letting the melter know when the tuyeres overflow. If they do, I have found arranging a number of holes in the bottom of the wind box and lining the bottom with daubing to conduct the iron to these holes and lightly tapping a wooden plug into the hole, the iron will run down to the wooden plug, burn around it, and the plug will drop out and the iron follow.

It is said of clays used for mixing with sand for repairing the cupola lining, "A clay having a high degree of plasticity with a lower fusion point is preferable to one with a high fusion point and lower plasticity." If this be true, much depends on the ability of the sand mixed with the clay to resist fusion. On the plasticity of the clay depends the ability of the daubing to hold in place until dried or set, and on clay and sand forming the daubing, the ability to resist the intense heat to which it is subjected. Though you may dig your clay and sand in your foundry yards, it is not cheap if lacking in these important properties. A daubing that will melt or sag down over the tuyeres bridging and bunging up the cupola is the most expensive kind of clay and sand.

When repairing the cupola lining the slag hole is formed, if the slag is to be tapped. This should be placed below the line of the lower tuyeres and between two, avoiding as much as possible the air playing on the slag hole when slag starts run-

ning out. After it has once thoroughly started, it makes little difference. Also far enough below the tuyeres so as the slag rises to the slag hole it will not flow into the tuyeres. In making the slag hole have it large enough to allow the slag to flow out fast enough, but close it with a mixture of molding sand and molasses water and place weight enough against it so it cannot be forced out by the blast. At the proper time it is easily opened.

Many melters form the green sand bottom with too much pitch and endanger themselves and others by the manner the stream of melted iron leaves the tap hole. Only enough pitch is required to drain the melted iron from the cupola.

While the greater part of the cupolas are still fired with wood, within a few years oil burners and gas have come into use in many of the large cities, where an ordinance is in force requiring the abatement of what is termed "the smoke nuisance" —referring to the smoke from manufacturing plants' chimneys and cupolas. In changing from firing the coke in the cupola with wood to firing with either of the above fuels in connection with compressed air, no change in arrangement of cupola is necessary, if the breast opening is high enough. After the sand bottom is put in, it was formerly the custom to cover it with pieces of waste boards, and on these build channel-ways with the coke from the breast opening to the back of the cupola by laying pieces of coke end to the channel-way, leaving them a little way apart and forming the channel-way some five inches in width. This channel-way is then covered with larger pieces of coke left some little distance apart, and a part of the bed charge is placed on top. The oil, or gas burner is then placed in the spout, keeping the nozzle of burner back from the breast opening some four inches that the tip may not become melted off. After the burner is lighted, the flame is reduced to blue at the burner, merging into purple and tipped with yellow, which finds its way through breast opening in among the coke through channel-ways and spaces between the coke.

If carbon or kerosene oil is used, a low air pressure will answer, but if fuel oil is used, a higher pressure is required. Say some twenty-five pounds with the first and sixty to eighty pounds with the last. With kerosene oil, it usually requires about twenty-five minutes to ignite enough of the coke, so that the oil may be

shut off and the burner be removed, some five quarts being used to fire the coke in a cupola lining up about thirty inches. With fuel oil, it requires some five gallons and about an hour to fire up to sixty inches thick. On removal of the burner natural draught completes the firing of the bed, or the blast is put on for a short time. In using the boards a small amount of smoke results, but experience has demonstrated the use of the boards to be unnecessary, as the heat from the burner fuses the top of the sand bottom in front of the breast opening. When illuminating gas is used in a forty-eight inch cupola, it requires some 200 cubic feet with an air pressure of about eighty pounds.

The height of the bed charge above the tuyeres is not always properly arranged. I have seen too much, also too little coke used. The melting point of the cupola is best determined the morning after a heat, by examining the condition of the lining, and afterward by experimenting with different amounts of coke, one is able to determine with the bed charge at what height the cupola will do the best work in melting, and the quality of the iron is to be taken into consideration. In one sense, the cupola will make its own melting point, but it may be slightly raised, or lowered by different heights of bed charges, and the amounts between charges. While too high a bed charge is a waste of fuel, too low a bed charge allows the air from the upper tuyeres to enter too close to the bed charge of iron, and unless the bed is raised by subsequent coke charges, the melting and quality of the iron is affected through the entire heat, producing a harder, poorer quality of slacker iron.

While I wish the melting to begin so I may bod up and then tap out within a reasonable time, I am always suspicious when I see melted iron commence to run very quickly after the blast is put on, unless the cupola has been charged and allowed to stand longer than the usual time. With a high bed more time is required between the time of giving the cupola the blast and bodding up, also before the first tap into the ladle. But, unless the height of the bed is very excessive, I prefer the high bed to one too low, as I can obtain a better quality of iron. Saving by using too low a bed charge of coke is poor policy in my estimation. The proper amount of coke to be used after charges are determined by weighing the coke and charging different amounts

of iron and watching the cupola during melting, noting the condition of the iron, in connection with speed in melting, as time required between taps in proportion to the amount obtained.

The condition of the bed when ready for charging if using coke, should be level with the fire showing between the topmost coke, and the wood completely burned, which is usually denoted by a freedom from smoke. At the Buckeye Engine Company, we have four cupolas, lining up respectively 72", 48", 24" and 12". Each has its peculiarities. I dislike very much to be obliged to put on the blast when firing the bed charge, in order to hurry it, when firing with wood, as I find invariably poor results are obtained at some stage of the heat. If using an oil or gas burner, I could not see such a marked difference.

In making up the breast and forming the tap hole, leave the breast some two and one-half inches in thickness around the tap hole for a cupola lining up some thirty inches, and three for one lining up seventy-two. Some melters make the breast too thick and are constantly in trouble.

During the melting the more level the charges of coke and iron are kept and the more even the blast pressure, using care to avoid charging pieces of scrap into a medium sized, or any cupola in such a manner as to cause danger of hanging up a charge, thus allowing the charges to settle evenly and regularly, the more even and regular the melting with a better quality of iron resulting.

If the charge of metal is part steel, this is charged upon the coke, but kept from in front of the tap hole, and the harder iron is charged next, and softer last. On the other hand, if a softer mixture is charged, the pig iron is charged first, and scrap last. As we melt many large pieces of scrap requiring the united efforts of three men to lift or roll them over a plank into the cupola, I am not seeking to obtain high melting ratios, but a fair ratio with a quality of iron suitable for my work. But I prefer to melt the iron hot as I contend a better quality of iron is obtained, and slack it down as required by the molds.

At present, I am using the seventy-two inch cupola, and firing with wood. We place ten baskets of coke on the wood, and when it is partly ignited, twenty-eight more, and level with two more. The coke weighing seventy pounds to a basket, I

have 2,800 pounds of coke. On this I place 5,000 pounds of iron and then two baskets of coke and 5,000 pounds of iron. If large pieces of scrap are charged, I should use three, thus, say the last I will have forty-three baskets of coke, or 3,010 pounds of coke, and 10,000 pounds of iron, and then six baskets of coke, or 420 pounds of coke, and 5,000 pounds of iron. If large pieces of scrap are used in these after charges, seven baskets of coke, or 490 pounds, and 5,000 pounds of iron and in nearly every case the last charges are reduced if using the 490 pounds of coke. This coke is of good cellular structure. Our chemist informs me that it analyzes: Sulphur, 1.15; ash, 11.44; volatile matter, 1.60; fixed carbon, 85.06 per cent. You will say, "Too high in sulphur;" to which I reply, "That is so." But, it holds up the charges well and does the work. The charges consist of 2,200 pounds of pig and 2,800 pounds of scrap in common mixtures. But whether the coke may be light in weight or heavy the bed charge of coke is always made the same height above the upper tuyeres and the amount of weight of iron in the bed charge changed to suit the difference in weight of coke. If using Lackawanna coal and gas-house coke, the coal was used on the bed, and the coke between charges. If using ordinary seventy-two hour coke and coal, one-half of the bed charge coke and this was charged first and coal on top of it, and between charges coke.

The gas companies are now making a heavier and more solid coke than formerly. The last I used analyzed some 85.60 in carbon, with ash 11.0; sulphur, 0.90.

Commencing with the fifth charge, limestone is added to slag the cupola and slag tapped, usually after melting 15,000 to 20,000 pounds of iron, or as soon as slag indications at tap hole show it necessary. The slag hole requires very little more attention. Forty pounds to the ton is used, and the limestone analyzes calcium carbonate, 92.20; magnesium carbonate, 1.90 per cent. The last charges require less.

It is to be remembered we charge the limestone to unite with the sand, ash and impurities of the iron and form a fusible slag that will rise on top of the iron in the basin and flow off through the slag hole when it is opened. Thus according to the amount, condition, and quality of the iron charged into the cupola with the quality of the coke, so is the amount of limestone

required to perform the work. If too much limestone is charged, it being in excess of what is required by the stock, it will work on the face of the fire-brick lining of the cupola as the fire brick are largely silica or acid, and lime unites with sand at a high temperature and forms a fusible slag. If not enough limestone is charged and one taps the slag, it does not flow easily, is sluggish, sticky and the blast soon freezes up the slag hole. If too much is charged, the slag will run like water, and the next morning the fire-brick lining will be found badly cut. We also use fluor-spar and tap the slag. This is not as hard on the lining.

If one is to charge limestone simply to obtain cleaner iron with small heats, or without tapping the slag, a little will go a great ways. I prefer marble spalls or fluor-spar. Oyster shells are used, but I dislike them on account of the phosphorus. In referring to the above, I deplore the fact that my knowledge of chemistry is limited, but I realize the recognition of the value of chemistry in foundry practice by founders in general, is due to the excellent work of the chemists and metallurgists.

In charging the cupola, many commence charging the limestone sooner, but I find our cupolas do better work commencing with the fifth charge, also that some cupolas are more easily slagged than others, though, apparently, conditions are the same.

When the blast is given the cupola, I insist on the tap hole being left open and allow enough iron to melt and run out to insure the iron is being melted sharp and all danger of iron freezing up in the tap hole, or in front of the breast is passed. I have been informed that if the tap hole were left open when the cupola was first given the blast, there was danger of the sand bottom in front of the breast being blown out of the tap hole. I never had such an experience.

The clay used for bodding up should not be of a kind that bakes too hard, as trouble is experienced with such tapping out. In using some, it is better to mix sand, sawdust or sea-coal with it, so the cupola may be easily tapped. Clays having too low a fusion point are constantly giving trouble when used for the purpose, as the cupola will tap itself out exposing many to danger. Do not use the bodding up clay too damp.

Building the breast out is often done by inexperienced cupola tenders, as they will tap out and do not see the tap hole

is clean before bodding up. If this is done, make up a large bod of daubing, shut off the wind and drain the cupola by making a large hole, and see all that is built out is removed. Then use the large bod and stop up and put on the first blast. Tap out carefully next time, and with a sharp pointed short bar, peck away around the hole and form a clean hole while the iron is running out and stop up. Profit by the first lesson and keep clean around the tap hole and use the right sized bods and the trouble will cease.

When bodding up, do not try to force the bod up through the stream of iron, but stand where you will be above, so you come down into the tap hole with the bod. Have an extra bod stick handy, for emergency the foreman may wish to borrow one with some bods of clay to stop a run out when some mold is being poured. Also have a sharp pointed short bar, they come into use when you least expect it. Wooden bod sticks are light, but one with a rod in the end having an iron head will last longer and will do better work. Remember a dry headed bod stick is hard to make the clay stick on, dip the head in water.

When the cupola is making slag, it is poor policy to allow all of the melted iron to run out of tap hole and let the slag follow it. Once let this occur and the tap hole is hard to bod up and keep bodded up, as a thin film of slag is formed around the tap hole which melts, and the bod is forced out by the pressure of the iron collecting in the basin of the cupola. When one sees the slag commencing to run out of cupola on top of the iron, bod it up. A coating of thick gummy slag on top of a ladle is hard to skim off and leave a clean ladle, and cleaner iron can be poured from a clean ladle than one bunged up. Owing to accidents, at times the melted iron finds its way through between bottom doors, or through the doors; keep cool, let the other fellow get hot. Tap out, shut off the wind, and when the cupola is drained with an extra large body of daubing placed on a board and with a brace under the board, force daubing into the hole, support the board, wait a few minutes, put on the blast, and the heat can generally be run off.

During the melting of the last charge or two, I find it pays better to reduce the blast pressure, unless, perhaps, particularly

sharp iron is wished. The charges of limestone are reduced, but with a heavy blast pressure and the slag in the cupola, if rich in lime, not having the quantity of stock with impurities and sand to work on, this attacks the lining as explained. In watching the workings of the cupola, I am led to believe more cutting takes place during the latter part of the heat with a high pressure than with a low. I can also remember slag being pumped out of the charging door at the last of the heat.

The iron obtained from the drop is a source of trouble in many foundries, and some prefer to drain the cupola of all iron as far as possible, and wheel the drop next morning to the dump. I cannot agree with them in wheeling the drop to the dump, as I have found dumps that were veritable iron mines, but the less shot iron I have the better. I charge it by either scattering through the charges, or charging in a body with enough pig iron to soften and pour in to work, which will stand a variation in either direction.

When dropping the bottom, beware of damp floors, there have been some bad accidents from this cause. Keep the floor dry in front of the cupola.

The height of the tuyeres above the sand bottom has been a question often discussed. This should be governed by the class of castings produced and facilities afforded for handling the melted iron. In a foundry producing light castings, the facilities afforded for handling the melted iron quickly, admit of lower tuyeres than where heavier castings are produced. In the first, the castings being light in weight require smaller ladles for pouring and these can be quickly handled, and with the size of the tap hole arranged in proportion to the speed in melting and with a tilting spout and other facilities for handling the iron, stopping or bodding up the cupola is not required so often. In the smaller foundries, the cupolas are seldom slagged. Where tapping the slag is practiced, the tuyeres must necessarily be higher. Where large ladles are in use holding large bodies of iron, they are not handled with the speed of the smaller, and a large body of iron must be tapped into them, in order to hold the heat until the second tap, thus a deeper basis is required. Many can remember seeing a small body of melted iron tapped into a large ladle with the result that it became very slack before

a sufficient body of iron could be obtained. Lower tuyeres give greater melting ratios generally, as less fuel is required for the bed charge.

As I understand it is the custom in some countries to provide forehearths, or receivers, into which the melted iron runs from the cupola, thereby obtaining a greater melting ratio with a more thorough mixture of the iron and thus producing a better quality. Transferring iron from one ladle to another, or tapping into a ladle in front of cupola, gives good results.

Experience has taught me, it pays to charge the cupola and let stand some thirty minutes before giving it the blast. The charges having become heated, the cupola starts melting sharp and clean, and continues so during the heat. A cupola starting to melt the iron slack and slowly is hard to regulate to produce sharp iron, and will often continue melting the iron slack during an entire heat.

The size of cupola charges is often discussed. Many find it to their advantage to use small charges, as with a large quantity of one mixture of iron, one can regulate his charges in a manner to obtain the greater speed in melting with greater melting ratios, than one who has various mixtures of variable amounts to obtain from the same cupola during a heat. Some cupolas will melt faster with larger charges than with small. There are many conditions exerting their influences to determine the size of charges other than the size of cupola.

In an engine foundry, we have cylinders of various sizes, gas and steam requiring varied amounts of iron. To-day, I may have a gas engine cylinder, requiring some 3,500 to 4,000 pounds, I wish a special mixture, and I charge it first, as I can obtain with more certainty the desired result in my mixture in the casting, and separate it from the succeeding charge with a larger charge of coke than really I wish. Thus I to a certain extent burn coke. It is well known and acknowledged that on general principles in a cupola there will be a mixing of the last of one charge of iron and the first of the succeeding. The first charges one can figure with some certainty of just what they are obtaining, but there comes a time when the average man loses track, and for this reason, one lays out before charging just how he is going to pour off the work molded up, especially large

castings, and makes up the charging sheet accordingly. When I am compelled to use smaller bed charges than 5,000 pounds and separate them accordingly, my melting ratio is less. Ordinarily, when a soft iron follows a hard, one can arrange the charges by making allowance to either over-draw the first and use part of the second, or one can start to pour the softer iron immediately after the first, or charge a greater amount in the first charge than desired, and then pour the second ladle into some work which will stand variations in either direction. On the other hand, if possible, I charge as first described and obtain a higher melting ratio.

The smaller the cupola, the smaller the pig iron and scrap must be broken for use. Greater melting ratios are obtained with pig iron broken into smaller pieces and with smaller pieces of scrap, but the cost of breaking is to be considered.

While the majority of cupolas are charged by hand, charging machinery is being introduced for charging the larger cupolas, using compressed air to dump cars loaded with the charges, or charges are weighed up in trays made of boiler iron and loaded on tram cars and dumped by various arrangements, by cranes, or some mechanical appliance worked by hand. As more attention is given this manner of charging, future appliances will be found more satisfactory. At present the claim is made that by other modes than hand charging, the iron and coke are dumped at one side of the cupola. While this is true with some methods if charging the trays commences too early. One of the most successful men in handling this question I ever met, claimed that the cupola should be charged by hand until a height some four feet below the charging door was reached and then charging with trays commenced. In his manner of charging, the tray was placed with one end resting in cupola and the other end was raised at high speed with a crane, and the desired result was obtained.

It is also claimed that long, narrow trays allowing the charge to slide out, deposit it on one side of the cupola, while a car arranged with a side dump, so the charge may be tipped into the cupola, gives the best results. In charging with these appliances, it is found the cupola requires to be some four feet higher between upper tuyeres and charging door than when

charged by hand, and charges must be allowed to settle to that distance before another charge is charged. Thus the charge has a chance to spread itself in falling.

While much more may be said, did space or time permit, let me close with, the successful management of a cupola requires a study of cause and effect, and attention to details, the doing of the right thing at the right time, and using the right quality of supplies. Few cupolas of the same construction and size work alike. Neither will all men use the same blast pressure, as they use different arrangement of tuyeres.

I am reminded of my old melter in Montreal, who on being complimented on the workings of the cupola remarked, "But she needs a deal of pettin'." Each cupola seems to have an individuality of its own, and it is studying this individuality that gives success.

AMERICAN FOUNDRYMEN'S ASSOCIATION

THE EFFICIENCY MOVEMENT IN THE FOUNDRY.

By C. E. Knoeppel, New York City.

You have all heard so much of late regarding "Efficiency," "Scientific Management" and "Standard Practice," that it is but natural for you to ask the question:

"What is there in it for me; for my business; for my industry?"

As a body of progressive manufacturers you are naturally inclined to listen to anything which may mean greater success in the conduct of your business. The task is, therefore, to discuss this new doctrine with specific reference to your own industry—the aim of which will be to explain what it is, why it is necessary, how it works, and what it means for you and your men.

The success of any business is but the sum total of the successes of the factors making up that business, and whether these factors are men, or materials, or machines, or methods, the rule is exactly the same. If only a few men are doing all that is possible; if materials are not being handled to the best advantage; if machines are idle part of the time; if methods are capable of being improved, maximum results cannot be obtained. There may be several ways of doing a thing, but there is only *one best way,* and the executive who does not search diligently for this best way is blinding himself to the possibilities in the law that commerce is but the adjustment of a number of relations to a financial end—the better the adjustment, the greater the results.

The foundry business, the same as any other business, should be based on *mutualism.* The executive wants low costs, the men employed want higher wages, and there is no reason why both should not realize their desires. If either ignores the interests of the other, *both lose out.* The aim, therefore, of "Scientific Management," or whatever you choose to call it, is to bring about this seemingly illogical condition of higher wages and lower costs, through finding the best ways of doing things, and prop-

erly adjusting the various relations to the end that the proposition may be in the best possible working condition. If you will think of this doctrine of efficiency in this sense, the possibilities will no doubt appeal to you.

It is only within the past few years that the right kind of attention has been given to the matter of conserving our natural resources. We all know that this must be attended to, for we cannot only see this waste in material things, but it is felt in a business way—it touches the pocketbook. Did it ever occur to you, however, that there are enormous wastes in every phase of human effort, and that it is just as vital to take steps to stop this waste and conserve our resources in this direction? Every one will agree with the statement as regards material things, for the waste is a measurable quantity; while as to effort, the waste is more difficult to point out, hence more difficult to measure—it is with us, however, and sooner or later the right kind of attention must be given to it.

In a sense, our activities have been one-sided. The right kind of attention has been concentrated upon the tangible elements, while the more intangible, but equally as important factors, have received but a small proportion of the attention that is possible. You have your specifications as to metal; you have your chemist who determines your standard practice as to material; your coke problems have received the attention of the best minds; molding machinery is receiving its share of attention and is being constantly improved; the cupola and its workings is far from being neglected; you have your Standardization Committees; transportation facilities in a number of instances have been developed to a high degree; in fact, all through the material and physical branch of your industry you have realized that it paid to first collect facts, then study these facts, and finally apply the best methods that your study revealed. How about the man end of the game? Has the same thought and study been applied to this branch of your industry?

Waste is the difference between what happens and what should be, and because this is so, we have to consider the elements of standardization, against which performance is compared, the result of which is a factor of efficiency—high or low—depending upon the care with which we set a standard, or the

effort exerted to attain it. Consequently, you are confronted with two problems:

(1) The setting of the right kind of standards.
(2) The effort expended to attain them.

It has been said that business is a warfare between the management on the one side and the men on the other; in fact, an editor of a leading magazine said, a few years ago:

"Either side gets just what it grabs; hence, if I were a workman, I would go back into the union, and fight fiercely for a high, straight wage and eight hours, and if I were an employer, I would fight for straight piece work. Either side will get just what it has the power to take. It is the law, the fight of life."

Without going into the merits of this statement, it is, nevertheless, true that in the past there has been a feeling on the part of the men that before they did more or all that was possible, they would have to get more in wages; while, as regards the management, it has been considered that enough was paid for what was being turned out. As a result, both sides have suffered. If, therefore, a method had been devised for a more equal division of responsibility, and a greater gain to the men for an increasing output, it would have meant a getting together, which would have increased earnings for both the men and the company.

By those who have had the opportunity, through actual experience, of studying the conditions as they exist, in an effort to better them, two conclusions have been reached.

(1) That a man can accomplish considerably more than he does.
(2) That the management, as business is at present conducted, does not know what constitutes the best a man can do.

A few words as to the evolution of your industry will serve to show why this is so. Up to the present time, the molder has learned his trade largely through observation. He starts in as an apprentice; watches his fellows; gets a few pointers from them, and an occasional word from his foreman. He develops as well as he can under such conditions; drifts around from shop to shop, picking up points as to the varying lines of work, and in

time becomes a full-fledged molder, his success being largely a matter of mentality, initiative, and the incentive furnished him to use his brain and muscle to the best advantage. In any foundry, he starts in as a man who some one else has trained, and if he is able to make work of fairly good quality, with not too much loss and in a reasonable time, he stays. Is his subsequent training, however, anything beyond this mere manner of observing? On the other hand, if he does not suit, he is sent on his way for some one else to try out; when, under a constructive type of organization, his latent forces would be determined and brought out, and on the particular class of work for which he might be fitted, he would, no doubt, be successful.

As regards a foreman, the same condition is found. He comes to a concern trained through observation by some one else; is given a general idea of what he is expected to accomplish, but as he has a large number of men under him, his time for giving them the right kind of supervision is limited, and, as a result, he is in no position to study a job, properly standardize it, and see that the men attain the standard.

If he is better than the man before him, he stays until competition renders his best not quite good enough, when he makes way for another, who may not be as good, in which case he stays but a short time. If he is better, however, he stays until a higher level must be reached, and if he cannot attain this new level, it is figured that some one else can.

Even when the matter of management is considered, study will show that under present conditions a manager cannot work at his highest efficiency. The usual course is to engage a manager, to allow him a limited time in which to get acquainted with the conditions and the product, and after that to tell him to go ahead and get his results. His time is devoted to securing business; pushing the work through the shops, many times regardless of the cost; running a "diplomacy bureau" for the benefit of the customers; worrying about finances and getting customers to pay their bills; listening to complaints from his men; settling disputes and quarrels, and a thousand and one other things that an executive is called upon to do in the course of seven or eight hours daily. While so busily engaged, in spite of the fact that he may have facts and figures in abundance regarding what has been and is being done (which he uses as best he can when he

has a little time), it is easy to appreciate how it is possible, in the absence of a well-organized attempt to convert waste into money, for time to be lost, money thrown away, materials scrapped, etc., all because industrial endeavor seems to be conducted on the assumption that the more detail a man can look after in the course of a day, the greater he is as an executive and the more he should be able to accomplish. As a matter of fact, there is a limit to the amount of detail a man can handle, but practically no limit to the supervision that he can exercise.

What do we have as a result? The executive wants results, but he is unable to give more than a general idea as regards what he desires accomplished, so that it is up to his manager to reduce this idea into elements and factors, which he does as well as he can. The foremen are told that they must produce, and depending upon their ability they do as well as is possible in giving out the work, bettering conditions, stipulating how much they want produced, advising the men, etc. The men who finally get and make the work use their ability to a great extent in their own way. If they are not working fast enough or make their work incorrectly, it is not noticed except as the foreman in the travels around the shop happens to observe what is going on, in which case the men receive criticism or advice, as the case may be.

Because the conditions are often as outlined, it is not strange that through this shifted responsibility more is not accomplished. Men cannot advise themselves, and if the matter of equivalency as to time, number per day, and quality of product are left in a measure to them, or to a hasty observation by the foreman, it follows that because each man through his training is in a sense a "law unto himself," the practice is anything but standard.

To reverse the order of things, to build from the bottom upward, requires a constructive type of organization that erects on a firm foundation and in a scientific manner a structure that will consider the various elements entering into making the enterprise successful. These elements are:

(1) The man.
(2) The work to be done.
(3) The conditions under which he does his work.
(4) The planning of the work he has to do.
(5) Reward for individual effort.
(6) The records effecting the factors of the business.

As to the Man. What is he capable of and how can the best be secured from him? It has been found in handling pig iron that a man can do his best when handling 92 pounds at a time; in shoveling, 21 pounds to the shovel was found to be the best load; both being results of experiments made by Fred W. Taylor. In bricklaying, Gilbreth found that eighteen bricks constituted the best load for a man to handle, and that by studying the motions of the man, they were reduced from eighteen motions to five motions. It took scientific study to determine these facts, but they were worth while, for, as to pig iron, the increase per man was from 12½ to 47 tons; in shoveling, the amount was doubled or trebled; while in bricklaying the accomplishment per day rose from 1,000 to 2,700 bricks. Here, then, is a prime consideration—scientific study of the man.

In the foundry the work is largely a matter of motion—shoveling, ramming, slicking the mold, making cores, coring, finishing, closing, weighing, pouring, etc. Considered in this light, there are wonderful possibilities ahead of your industry in this particular field, if we judge by what has been accomplished to date in this and other lines. As to the foundry industry, little, if any, study has been given to motions, trips, extra handling, etc., to determine the best a man can do, day in and day out, without injury to his health, for it should be remembered that scientific management does not mean slave driving. So much for the practical side of the man's work.

The psychological side of the man is beginning to receive its share of attention, and again, as regards your industry, there is a productive field awaiting development. We are all more or less governed by self-interest, and as every man possesses such faculties as initiative, imagination, energy, interest and concentration, any appeal to this self-interest awakens each faculty and more is accomplished as a result. Those among you who have made the greatest successes have been inspired primarily by self-interest. You called your imagination into play, dreamed of future successes, drew up mental plans which you desired to carry out, which aroused your interest to such an extent that your whole aim and purpose was centered upon what you had planned mentally. Depending upon your interest and concentration, your faculty of initiative forced you to get up and do, and your energy carried you through

to success. These same qualities exist in every man. To what extent have they been developed in those under you? If, in addition, we consider that there is such a thing as a "second wind" in a mental as well as physical sense, the development of this side of a man's make-up is worth while undertaking.

In studying men, then, we must analyze what they do and how they do it, eliminate the unnecessary, instruct them how to do the necessary, inspire them with new and fresh interests, furnish them the incentive to use their heads and hands to better advantage, and you can get results from them which will be surprising as well as profitable.

As to the Work. The task is not completed, however, by just studying the man, for there must be a knowledge of what he has to do, as well as how he is to do it. The foreman can hand a molder a pattern; the molder can have a flask brought in; he can make and pour the mold, but he assumes a greater responsibility than is really his. Study will soon demonstrate that there is the unnecessary in the operations that go to make a job, just the same as there is the unnecessary in the work of the man. If the molder goes for gaggers, and then in setting them takes longer than is necessary, you have a double inefficiency, so that in studying the work the operation of going for gaggers would be eliminated, for the very good reason that a concern does not get productive capacity out of a molder when he is doing something that can be done for him by those less skillful and at less expense. This illustration holds as regards other items, such as mixing facing, going for nails, chucking or tightening flasks, and a number of other details that a study will reveal as existing to a degree in almost every foundry. Eliminate these unnecessary features, and you can standardize the operations; you can plan more intelligently, and you can put the responsibility for making a good mold squarely up to the man, not a responsibility that is likely to be detrimental to his interests, through furnishing him with tools and rigging that may not be best for the job in question, making him wait unnecessarily, etc.

As to the Conditions. After you have studied the work, separated the productive elements from those which are merely preparatory operations, it is then up to the management to assume full responsibility for bringing these conditions to the highest

degree of efficiency. The molder, in a broader sense, is only the medium between the finished casting and what he is given to work with, as well as the conditions under which he works. We are all familiar with what he uses in his daily work, and as a molder can work efficiently only when he can use to advantage such items as patterns, cores, flasks, sands, nails, tools, etc., it would certainly pay to have this end of the work at its best. In a brief way the conditions capable of study and betterment are:

(1) Foundry orders—knowledge of and their following up.
(2) Storage and handling of materials, supplies, etc.
(3) Selection of patterns, sweeps and core boxes.
(4) Repairing and altering the above.
(5) Selection of flasks.
(6) Repairing and altering the above.
(7) Flask storage, piling, etc.
(8) Removal of castings, gaggers, rods, etc., from the sand.
(9) Tempering of molding sand for use by molders.
(10) Mixing of facing sand.
(11) Shop carrying arrangements.
(12) Supplying the molders with facilities.
(13) Furnishing the molder with proper tools.
(14) Crane facilities.
(15) Arrangements as regards the general shop labor.

As to Planning. One of the reasons for inefficiency in industrial endeavor is a lack of, or faulty planning, or dispatching, as it has been properly termed, the assumption of which is—no work is ready until everything is, or will be ready for the work. If the molder has to wait for a job, or pattern, or flask, or his cores, or to have new bars placed in his cope, faulty planning is responsible for inefficiency, which taxes the work with more than it should cost.

The elements of efficient dispatching are as follows:

(1) The parties concerned.
(2) Planning.
(3) Execution according to the plans.

All of these must receive proper attention. As to No. 1, this would consist of the foreman and those responsible for cores, flasks, rigging and shop labor. The next step—the planning—involves the following:

What is to be made?
By whom it is to be made?
Where it is to be made?
When it is to be made?
How it is to be made?
With what it is to be made?

While the execution is made up of three divisions:

(1) Knowledge of the plans made.
(2) Preparation for carrying them out.
(3) Carrying out the plans as per schedule.

If dispatching as above outlined is placed at the service of the men as regards jobs, patterns, flasks, cores, rigging, special features, conditions, the night work, supplies, crane service, tools and equipment, shop labor, etc., it would be but a short time before gains due to this one feature of the work would be such as to convince you beyond any possibility of questioning as regards the merits of efficient dispatching.

As to Reward. With dispatching so arranged to eliminate waits and delays; with conditions in the best possible state for working to advantage; with the work standardized both as to productive operations and as to time in which they should be done; with the men under proper direction giving their best energies, who is there unwilling to divide with them a share of the gain due to the elimination of waste and unnecessary effort? This would stimulate them, awaken a self-interest, and they would not only willingly assume their legitimate responsibility, but co-operate with you in turning out more.

This reward would be based upon individual merit according to the efficiency of each man, as shown by the relation existing between the time actually taken by him and what he should have taken on work that had previously been studied and standardized. In addition, rewards would be entirely distinct from wages, so that the men would have everything to gain and nothing to lose;

in fact, the more a man could earn the better, for this would mean a higher efficiency, which stands for a low cost.

As to Records. Studying out the problem and drawing up the right kind of records would place in your hands actual and standard times and costs, efficiency of men, machines, foremen, departments and of the business as a whole. Such information would not only prove of value in enabling you as executive to keep in touch with the weak spots, but it would serve as the basis for rewards for individual efforts; as a guide in bettering the places needing attention, and as a means for better estimating and pricing, for you would in time have a standard accounting enabling you to know in advance what things should cost.

In a few words, scientific management is the proper locking together of the six elements mentioned, each studied with reference to the others, the basis of which is a factor perhaps most important of all—*the fair deal*—for if the work is not based on justice and fairness, mutualism is not going to be the result that is absolutely essential for success. On this basis, organized labor has nothing to fear from this new type of management, for it is far from being a take-all-and-give-nothing proposition. It recognizes that there is a human element to be considered. Labor may be suspicious and "from Missouri," but as the underlying principles of this new doctrine are applied and understood, they will in time come to the realization that it is a movement in the right direction—a move intended to benefit them as well as the concern for whom they are working.

What Are the Possibilities? Efficiency methods are applicable to your men as to the motions made and their psychological side; to the molding operations; the making up cores; the cleaning of castings; the cupola; the handling of materials and supplies; the use to which they are put; the physical conditions; the removal of castings at night; rejections, to determine and eliminate as far as possible preventable causes and other elements, all of which could be made to yield their share of gains through scientific study; setting up ideals and making it an object to those concerned to attain them.

Would It Pay? Fred W. Taylor states that he made 30,000 to 50,000 experiments on 800,000 pounds of iron and steel, spending from $150,000 to $200,000 in an endeavor to get tool making

down to a positive science. How well he succeeded is evidenced by the remarkable progress made in machine-shop practice, since the introduction of high-speed steels and a knowledge of the kind, shape and cut of tools, feed and speed of machines, etc. So with this matter of introducing efficiency methods. It will take time; it will cost money; it will have to be in charge of fair and open-minded men; it should be looked upon as something to be "put thorough" instead of simply "tried out," but in the long run it will prove its value, as it has done to date, in a variety of lines.

To sum up briefly: We have in our midst wastes due to the inefficiency of human endeavor as well as the inefficiency of material things. On the one hand, there is the prospect of allowing this condition of affairs to exist or changing these conditions through a better and more efficient type of management—a type having fixed laws and clearly defined principles applicable to all line of endeavor.

Getting back to the question asked at the outset, there is everything in it, for it means the elimination of loafing and soldiering; it will exert a powerful influence in eliminating disputes for the basic consideration—a fair day's work will be a matter of scientific determination; the men will earn greater amounts; costs will be reduced; co-operation will be secured; instead of discharging men or cutting their wages, efforts will be made to bring them to a higher level; you will in time gather together a mass of information on a variety of subjects which will constitute your standard practice; there should be no danger from strikes if the work is properly introduced, and the result can only be that you, your business, your industry and in time the whole country will feel the result of a management based on fairness, a proper division of responsibility and reward to those who assist in the elimination of wastes.

PATTERN MAKING AND PATTERN EQUIPMENT.

By W. S. Giele, Philadelphia, Pa.

Introduction.

The scope of the subject in hand is so broad that, within the limits of the time allowed for its preparation and for its presentation to the association, it would not be possible to go into detail in any of the many ramifications into which its study might lead.

There has, therefore, been no attempt to go into such detail, and, indeed, many of the very important branches have not been mentioned at all.

The object has been rather to discover, if possible, such fundamental principles and tendencies of development as will be of general application.

The larger problem of economic and efficient equipment subdivides itself into secondary problems as applying to a particular case. Each of these secondary problems finds its solution developed to the highest degree, if not to the ultimate ideal, in specialized industries, in which it happens to be predominant.

Advance must come through the general application of these specialized developments.

With the above in mind, a number of specialty foundries have been visited and manufacturers of equipment consulted, the secondary subjects being treated with a view to bringing out, as far as possible, the general application of the special solutions.

It is hoped that the discussion will supplement what is lacking in the paper, and that the information so brought out will contribute to the advance of the art.

If there is one tendency predominating all others, it would seem to be in the growing substitution of mechanical for manual operations, both in the construction and in the use of the pattern equipment, and such tendency, if it is to continue, must take the form of adaptation of the mechanical processes and machines involved to the requirements. This adaptation is best illustrated by recent developments in woodworking machinery, paralleling

contemporary developments in machine tools with such modifications as are required for woodworking processes.

Another example is in the development of simple, economical and rapid methods of mounting patterns for use on molding machines, so that the machine becomes available for the production of castings required in comparatively small numbers, as well as for production of large numbers of castings from expensive and highly developed pattern equipments.

As there seems to be no logical basis according to which the subtitles can be classified, no such classification has been made.

Stoves.

The making of stoves presents several striking and characteristic features as distinguished from other branches of the foundry art.

The castings are assembled or "mounted" without having machine work done on them, so that while accuracy of size and shape is not important in the finished structure as a whole, accuracy of fit between parts is absolutely essential. In fact, it would be impossible to build up the stove if the fits between castings did not make such close joints that they could easily be sealed air tight and also make a good appearance.

The requirements peculiar to this industry have developed methods which do not rely on any abstruse theories nor on scientific accuracy of measurement, but which depend on common sense and care in execution. The basic principle may, perhaps, be said to be the combination of a highly trained eye with the judgment which cannot be embodied in rules, but which comes only from experience.

The writer found at one large Eastern stove concern that, given the requirements for a new "piece of goods," the designer or, perhaps more properly, the "architect," first constructed a mental image of what was wanted, and then, bearing in mind the types and patterns on hand, gave it tangible form, sometimes in a clay model and sometimes as a sketch drawn in perspective and shaded, a picture rather than a drawing.

After this had been thoroughly discussed and made to embody suggestions from all departments (co-operation is a real force in this plant), it was laid down as a full-size drawing, showing all parts, and *not dimensioned*.

The drawing then goes to a gang of pattern makers who make the master patterns, taking their sizes direct from the drawing. For convenience of distribution to the workmen comprising the gang, the separate details may be traced from the general drawing.

As the castings are very thin, the wood patterns are, of course, extremely delicate, and the methods which are familiar to the stoveman are a revelation to many a foundryman in other lines.

For instance, curved pieces are occasionally bent to shape with an expenditure of labor and material but a small fraction of that required to build up and work out such a piece. Possibly such patterns would not be very durable under ordinary molding conditions, but in this case they are follow boarded and used only in the production of metal working patterns.

Another feature interesting to the stranger is the production of such irregular shapes as a stove foot, for instance. This compound curved surface, with not a point to measure from, would defy the ingenuity of many a mathematician, but many of those present have seen the woodcarver in a stove pattern shop produce such a piece with apparent ease, working out the exterior surface first, then drawing in the scrolls or other design, curved lines on curved surfaces, and carving them out. And he depends on the eye and on the hand for symmetry.

Few foundrymen have not had difficulties with castings of uneven thickness, and the importance of this is nowhere more vital than in castings which average less than ⅛ inch in thickness. Here, again, the stove foundryman relies on positive common-sense methods rather than on refined measurements. Thus, the leg above referred to, after the outside has been shaped and carved, is cut away at the back, following every irregularity of the design and keeping the metal thickness constant by gauging at every point by means of the well-known tool sometimes called "scissors calipers." Even in the case of a gas stove burner, the half-pattern is shaped inside and out to a constant thickness of metal. Working patterns made from the outside and working core boxes made from the inside of such a master, by molding processes, will insure castings of uniform thickness.

On this general class of patterns follow boards are not only

required to form the parting in the mold, but are essential to support the pattern against springing during ramming. It is often convenient to carry the construction of the follow board along with the construction of the pattern, using it as a support for the pattern when working on the exposed side.

In stoves, as well as in other lines, where one design runs through a line of sizes, great economies can be effected by standardization of elements, any one of which may be used in a number of different sizes and even in the standardization of pattern elements. Standardization of core prints is too obvious to deserve mention, but other elements can be treated in a similar manner.

For instance, the writer saw a master pattern for an oven door with expensive carved flanges and corners made with two lines of division at right angles to each other, so that it could be extended in both length and width. This one master was used to make a number of working patterns of different sizes and uniform design. The advantage of the follow board support in the case of this divided pattern is self-evident.

This association need not be reminded that shrinkage allowances are adjusted to the number of steps and kinds of materials intervening between the original pattern and the finished casting. Thus, in the case of the oven door cited, a master pattern is cast each time the original wood pattern is changed and the working patterns cast from these.

The original masters are not always made in wood. They are sometimes made in very soft metal which can be shaped by hand, and melted down so that the material can be used over after the secondary master pattern has been cast.

Once the master patterns are completed, they are assembled into a model stove, the simplest, surest and quickest method for checking all dimensions:

The working patterns are probably most frequently of iron, though also made of aluminum, white alloys and brass, the choice of material being governed by exactly the same considerations that would apply in any foundry.

The foreman of the pattern shop is properly held responsible for the quality of the patterns, and, therefore, properly the one to pass on the quality of the castings for working patterns.

The castings are sand blasted and then pickled to remove the

scale, after which they may receive a preliminary polishing on a wire wheel brush for irregular surfaces, and an emery wheel for flat or convex surfaces.

The main work, however, is done by hand with file, scraper and emery cloth, and no man who has ever tried to mold a pattern in sand will deny that too much care cannot be given to finish and particularly to draft.

The working patterns, like the master patterns, are checked by being mounted as the castings are to be, rather than by measurement, and in this final fitting judgment and experience count for more than theory in deciding just how much allowance should be made for the casting operation. Thus, the cope side will not be rapped, the drag side will, more allowance must be made in shoulders on the drag side than on the cope side.

The final test is a sample set of castings made from the patterns and assembled into a stove.

This is a very general view of the method of developing an equipment of patterns for making stoves as practiced in the manufacture of heating and cooking stoves, gas stoves, steam and hot water boilers. The patterns for small parts particularly, and for some of the large parts as well, are mounted on plates or fitted with stripping plates for use on the molding machine, as will be treated elsewhere in this paper.

Gating on these thin castings is important, as the gates must be of ample area to flow the metal over the whole of the mold without the formation of cold shuts, and yet thin enough to break off without breaking into the casting.

The use of set gates or gates permanently attached to the patterns is preferred to gates cut by the molder, which are never twice alike.

Foundry, for April, 1909, contains an article entitled "Hinged Matchplates for Stove Work," describing the method in use by the Bucks Stove and Range Company, St. Louis, Mo. Their alloy for matchplates is zinc, 1; aluminum, 2. This alloy withstands severe foundry usage without being broken or bent. It has a high shrinkage, and in order to get it into the mold as quickly as possible, it is poured simultaneously from four generous sprues and a large riser is usually placed in the center of the mold.

The article referred to describes in detail the mechanical process by which the plate is made.

The construction of the hinge which maintains the proper relation between the mold parts and matchplates is also fully shown.

The depth of draft which can be handled by the roll-up process is greater than sometimes supposed. The writer has learned of one instance of 4½-inch draft, and doubtless some one of the members can cite a case of even greater draft so handled.

Sizes of flasks and illustrations of numbers of pieces of various kinds put into the flasks are shown in this article, as well as in a later article appearing in the March, 1910, issue of the *Foundry,* which latter describes the process developed at the plant of the Michigan Stove Company, Detroit, Mich., under the direction of W. J. Keep. The shrinkage of the aluminum-zinc alloy is here given as 0.146 inch per foot, that of the white metal in the secondary master patterns 0.04 inch per foot and the shrinkage of the iron casting as 0.125 inch per foot, making a total shrinkage allowance from the original master pattern to the final iron casting practically 5/16 inch per foot (0.311 inch per foot).

Still quoting from the same source, cast-iron matchplates are 2.6 times as heavy as those made from the aluminum alloy. Test bars show that this alloy has practically the same strength as cast iron, and in addition is free from corrosion.

The same article contains a detailed description of Mr. Keep's flask hinge and his methods for making matchplates.

The *Foundry,* for June, 1910, describes the practice of the Best Foundry Company, Bedford, Ohio, where stove castings are made almost entirely on molding machines. Follow boards have been practically discarded at this plant, being superseded by matchplates. The Best Company uses pure aluminum for its matchplates.

As all three of the articles above referred to show many illustrations of pattern equipments and describe the interesting features of the pattern-making processes involved very fully, it seems hardly needful to reproduce this same information in the present paper.

The equipment of the shop for making the patterns is interesting as well as the process.

Mr. Whitehead, superintendent of the pattern shop of the

Abram Cox Stove Company, of Philadelphia, has made a very effective arrangement in that plant by placing all the benches with their left ends toward the windows, thus economizing space, giving each man the best possible light and easiest access to machines, and lessening the temptation to conversation between the workmen, because each looks toward his neighbor's back. Mr. Whitehead's office is separated from the shop by a glass partition, and is at the end of the line of benches where he can see all the men.

The machinery is advantageously placed in a line paralleling the line of benches and near the center of the shop. The usual woodworking tools are provided. One which ought to be more usual in other shops than it is, is a first-class grinding machine for sharpening tools, carrying a revolving oil stone and a cone-shaped stone for gouges.

Another, in the same class, is a small jointer, taking such pieces as are usually planed by hand. The knives of such a machine are much more easily kept in perfect shape than on a larger machine, and it is a time-saver on work within its range.

Another time-saver is a rack containing, in marked compartments, perfectly seasoned and accurately planed stock in thicknesses of 8, 9, 10, 11, 12, 13, 14 and 15 to the inch.

The varnishing is confined to a room provided for the purpose.

The metal workers are provided with convenient motor-driven grinding stands carrying emery wheels and wire brushes that save much hand work. There is also a small portable electrical drill which can be attached to any lamp socket and taken right to the work at the bench or vise.

The soldering forges are gas fired in this shop, and arranged with a pilot light and automatic valve, the latter being operated by the weight of the soldering copper when it is laid into the forge.

The metal workers are provided with a small molding department in which the alloy patterns and pattern plates are cast, and in which the actual working of a pattern in the sand can be conveniently tested. This department has in it the furnaces for melting the pig metals from which the alloys are made.

The lessons to be drawn from the general methods outlined

as applicable to other branches of the art might be summarized as follows:

1. Starting with a definite notion of size and saving the time consumed in laying out a piece to scale and then laying it out again full size in the shop.

2. Saving in time required to dimension drawing and complication of drawing by dimension lines and figures.

3. Elimination of mistakes in putting down and reading dimensions.

4. Saving filing and reference systems. Each piece given a number, and the master or secondary master pattern giving an absolutely sure record of the piece. This method makes it possible to furnish repairs for stoves made fifty years ago.

5. Absolute checking of dimensions without possibility of errors in measuring by assembling patterns.

6. Concrete idea of appearance of finished product before it is made through assembled patterns.

Boiler and Furnace Castings.

These are comparatively rough castings on which little or no machine work is done, and most of which are built into the brickwork of the setting. Castings for incinerators, furnaces, driers and ovens belong in the same general class.

Of the castings attached directly to the boilers only the nozzles used for attaching pipe connections to the shells and the lugs or brackets which support the shell will be mentioned.

The interesting features in connection with the nozzles are, first, the familiar problem of a piece with a flange at each end, and, second, the coring of holes at varying angles such that the prints would not draw.

The first problem is, in the writer's opinion, best solved by making the flanges loose on the body pattern. The plane or pipe flange can then be drawn from the drag before rolling over and a cover core used. The curved flange can be changed to suit varying conditions, such as cylindrical shells and spherical heads of varying radii and radial or non-radial positions on either.

The rivet hole cores in these curved flanges, as well as in the curved flange by which the supporting lugs are attached to the shells are normal to the surface; that is, radial, and, therefore,

at such angles that the prints would not draw. This difficulty is overcome by drilling holes in the pattern and stabbing the prints.

Bases and conical hoods for vertical boilers present no particularly interesting points. The pattern equipment must comprise patterns for the various diameters of shells. The most used sizes are usually made from iron patterns, the rest frequently from wood patterns. The wood patterns being thin and of awkward shape, should be follow boarded for support, and both the wood and iron patterns ought to be follow boarded to save the time required to make the partings by hand.

Mud rings and fire door rings for vertical boilers are made from wood patterns, owing to the heavy section; these castings being equal in thickness to the water leg in the boiler. This pattern equipment also must include patterns for the various diameters of shells.

Boiler fronts, for convenience in molding, in handling and erecting the castings and for preventing cracks due to the uneven heating in service, are made in sections.

Even the smallest fronts have an expansion piece between the fire and flue door openings, where the severest temperature stresses come.

The largest number of fronts with single fire and ash door openings is divided into lower right and left fronts and top front. The joint between the lower fronts is in the bridge under the ash door opening, the bridge between the fire and ash doors, and through the expansion piece between the fire and flue door openings. The lower fronts usually extend up to about the middle of the flue door opening, where they join the top front. This arrangement permits of replacing the lower portion exposed to the fire without replacing the upper.

In the case of fronts having two fire door openings, the expansion piece is made "T" shape, extending usually from vertical joints, opposite the center of the fire door openings, to a horizontal joint between the fire door openings near the middle of their height.

The joints in fronts are usually made either lapped, the lap being cast on one member of the joint and overlapping the other, flush at the back, or by butting the plates and covering the joint with a lapping strip on the front. These lapping strips serve the

purpose both of joining the pieces and covering the inequalities in the edges of the plates where they come together.

The door openings are surrounded by shouldered beads. The bead adds strength to the front around the opening and allows chipping to fit the door. The shoulder in the bead makes fitting easier, but is more particularly for the purpose of covering slight defects in the fitting of the doors.

These defects, while not large enough to materially affect the working of the front in service, would disfigure its appearance if they were not concealed in this way.

The doors are occasionally fitted to separate frames bolted onto the front. In this case the openings have a shouldered bead, as in the case of doors attached directly to the front, and the backs of the frames are provided with chipping strips for fitting to the front.

This construction has the advantage of replacing door frames without replacing other parts of the front, and, more particularly, convenient fitting of the doors to their opening. In fact, the door frames can frequently be made up in stock and have the doors fitted to them in advance of the casting of the remaining plates of the front, thus shortening the time required for shipping special fronts.

The hinge lugs for the doors are cored for the hinge pin on the front or on the door frames, as the case may be, and are usually left blank on the doors, the hole being marked on the door lug from the cored hole in the front or the frame, after the door has been fitted, and drilled to match. This is done because it is much more convenient to handle the doors for drilling than it would be to handle the fronts.

The vertical edges of the fronts are usually finished with a bead and the top edge with a cornice, but occasionally the top is finished by a bead or an ogee molding.

The cornice patterns are usually of iron, and two sections or styles of cornice will ordinarily be found sufficient to cover a complete line of fronts. The patterns are made in various lengths, and usually stopped off in the mold to make intermediate lengths. The end sections of the cornice are finished by being turned back at right angles to the line of the front at the vertical edges of the front. In case of a single front this would occur at each side of the front.

In the case of battery settings this occurs only at the extreme left and extreme right of the battery. The joints between the sections of cornice are concealed by means of a shield, which usually bears the date on which the job is to be erected. This shield is generally placed in the center of single fronts, opposite the center line between fronts, where two boilers are set in battery, and frequently a shield is placed midway between each pair of fronts where more than two are set in battery.

In the case of battery setting, the joint between the adjacent fronts is covered by a pilaster. This construction makes a convenient means for tying in the two adjacent fronts by means of a single set of tie-rods, which pass through a space of about an inch left between the fronts for this purpose and which allows for expansion of the fronts when they become heated.

Besides door openings, beads and hinge lugs, the fronts are usually provided with tie-rod bosses or washers, and are cored for the tie-rods. These bosses and core prints, except in the case of strictly standard patterns, should be made loose, so that they can be moved on the pattern to accommodate various arrangements of tie-rods, according to the brickwork of the boiler setting and the buck stays.

In addition to these, fronts are often cored for the bolts by means of which the dead and arch plates are bolted to them and occasionally also for the bolts by which the grate bearers are attached.

If the front is used in connection with shaking or dumping grates, cored holes are provided for bolting on the brackets which support the operating levers, and also cored holes through which the operating rods will pass.

If fronts are to be used in connection with stokers, special openings for hoppers, etc., according to the design of the particular stoker used, will be necessary.

In cases where fronts are built for battery setting, the beads on the side are usually only on the exposed side at either end of the setting, and must be omitted on the abutting sides of adjacent fronts. This makes right and left fronts and center fronts, as well, where there are more than two in the battery. These are all made from the same patterns by simply moving the beads.

Where boiler manufacturers furnish standard fronts with their boilers, it is usual to make up complete iron patterns for the fronts, plates and other parts.

There is, however, a considerable demand for special fronts from engineers, architects, contractors, etc., and to match old fronts or to provide for particular forms of furnaces, grates or stokers. These fronts are subject to all manner of variations in the relative size, number and location of openings.

Such fronts are best cast from wood patterns, such patterns being made of the thickness of the desired castings, and supported by battens which are stopped off in the mold. As the plate portion of the front is comparatively thin, these battens provide a more solid portion for rapping the pattern and for the draw spike, and also facilitate the addition of pieces for making fronts higher or wider.

The patterns are usually checked before being put in the foundry by laying up the complete set of patterns as the castings will be assembled in the front, this manner of checking being similar to stove practice, where the patterns are assembled into a complete stove before being sent to the foundry.

It is frequently necessary, in order to support the patterns, to place bars across the openings. Where an opening is not tied together on all sides, it is necessary to cast these bars in the metal to prevent shrinkage strains from spreading or contracting the opening, these bars being cut out of the castings later.

The lugs, bosses and core prints are usually screwed or nailed to the front patterns, so that they can be conveniently located according to the varying requirements.

An expedient for locating special fire and ash door openings, without cutting up the pattern, is to tack a strip onto the pattern which will indicate the location of the opening desired by the impression which it leaves in the sand of the mold.

A core box, the desired size of the opening, and of the exact thickness of the plate portion of the pattern, is made and located in the sand of the mold by the impression above referred to.

The box is then filled with green sand, which is rammed and struck off flush with the top of the box, thus forming the desired opening in the casting.

Occasion for this method frequently arises where fronts are desired with single wide fire and ash openings, or with double fire openings and single ash openings, or both double fire and ash openings.

Front patterns are universally made flat on the back, and in such few cases, as lugs are required on the back of the front, either to support dead plates or grate bearers, these are made loose on the pattern.

In the case of special fronts, as above referred to, it is usual to cast both the customer's and contractor's, engineer's or architect's name on the front or on the flue doors.

Where fronts are regularly made for a customer, it is usual to place his name on a panel, which is either rammed into the mold or temporarily attached to whatever pattern may be in use. Such a panel saves a good deal of work in setting up the lettering, and adds to rather than detracts from the appearance of the front.

The doors for fronts are usually deeply flanged in order to stiffen them against temperature strains, to permit of fitting them to the fronts and to allow room inside the door for liner plates, which protect the fire doors from the direct heat of the furnace.

Even special fronts are usually made with standard doors, and the door patterns should be made up in iron. A considerable variety of door patterns is required, as they not only vary in size, but doors for the same size opening may be made in a single piece or in two parts, in which latter case a right- and left-hand pattern is required.

The flanges on the doors are usually of such shape that they can be molded by the roll-up process for drawing the patterns, and this process can be used for either hand-molding on the floor or with the aid of machines.

The flue door patterns are of considerable size, and would be extremely heavy if made wholly of iron. It is usual, therefore, to make these door patterns up in the shape of iron flanges carrying the hinge lugs, and so made that the center portion may be filled in with a wood pattern for the panel to be cast integral with the door (often carrying customer's name, etc.), or with the wood panel left out, the opening in the casting being subsequently filled in by riveting on a sheet steel panel.

Where flue doors are made rectangular, rather than following the curve of the boiler shell, one pattern can be used for right- and left-hand door, except that the lug for the closing handle must be moved from one end to the other of the pattern, so that the castings will be right and left hand.

The dead plates are plain, thick, cast-iron plates molded from wood patterns. The thickness of these castings permits a strong wood pattern to be made, and any other material would make a pattern too heavy to be handled. They are usually simply built into the brickwork of the setting, but occasionally furnished with lugs having slotted openings by which they are bolted to the front and sometimes also with a lip at the edge toward the furnace, which takes the place of the front grate bearer and supports the grate bars.

The arch plates are similar to the dead plates in size and thickness, but a little more difficult to mold on account of the arches. They are usually made from solid wood patterns, the arches being single or double, according to the fire door openings, and in the case of long arch plates a rib is sometimes placed on the top to stiffen the casting.

The arches are usually flared, being wider at the side toward the furnace than they are toward the side at the front.

Special and unusual arch plates are frequently cast from skeleton patterns, the skeleton giving the outline and shape of the arch and limiting dimensions, the remaining portion of the mold being formed by cutting out the sand between.

One of the most difficult arch plates to cast is that with the ends undercut, which is intended to support a brick arch. The undercut portion is usually made in this case by means of a dry sand core.

The cheek plates are sometimes used to fill in the space between the dead plate and the arch plate, and are of the same class of castings, usually made from solid wood patterns. They have no particular special features, except that in the case of flared arches they must be made right and left hand, and this can usually be accomplished by transferring the lugs either for bolting to the front, or to the arch, or dead plate, from side to side of the one pattern.

The stack plates are perhaps the roughest of all boiler cast-

ings, being simply built into the brickwork of the setting. They are frequently made by making a pattern only for the flange surrounding the opening and fitting the base of the stack, though occasionally a skeleton pattern is made, giving the boundary lines of the casting, the sand between being cut out in the mold.

The stack plates are often cast in open sand, the upper portion, fitting the stack, being cast down, and the side going toward the brickwork being the exposed side in the mold.

T-bars for covering the top of the setting and supporting the brickwork present no special features. The patterns are usually of wood, in varying lengths, intermediate lengths being made by stopping off the patterns in the mold.

The buck stays are made from wood or iron patterns, according to the size of the casting and the number of castings required from a pattern. The patterns are preferably made with dry sand cores for the openings through which the tie-rods pass. This permits of shifting the core prints to suit various arrangements of the tie-rods without cutting up the pattern.

The buck stays are usually made in T-shape section, and the bosses surrounding the openings are made to straddle the rib, so that they can be moved to any desired position along the length without cutting into the rib.

Wherever bolt holes are cored, it is advisable, if possible, to slot the cores, the long axis of the slot in one casting lying at right angles to the long axis of the slot in the other casting. If the cores cannot be slotted, it is well to place the core in the larger casting only, marking the hole in the smaller casting, which is easier to handle, after assembling, and drilling it.

The grate bearers are made single and double, in various lengths, usually tapered, being deeper at the middle of their length and tapered toward the ends.

Where castings of lengths intermediate between the patterns on hand are required, they are usually obtained by stopping off the ends of the patterns symmetrically, so that the deepest portion of the casting will remain in the center of its length.

The single bearers are used adjacent to the dead plate and bridge, while the double bearers are used between these where more than one length of grate bar is required to fill the furnace.

Two single bearers are, however, often used in place of the special double bearer.

Grate bars are most commonly single bars, double bars, group bars, Tupper or herringbone bars, Adams' bars, sawdust or pinhole bars, and circular grates for vertical boilers.

The single bars are simply molded flat, usually from hardwood or iron patterns, according to the number of castings of any one size required.

The double and group bars must be molded on edge in order to leave the green sand core between the sections of these bars. Like the single bars, they are usually made from hardwood or iron patterns.

The Tupper, Adams and sawdust bars are usually made in standard 6-inch widths, the body of the bar being 6 inches wide, less the amount of air space allowed between the fingers of the bar, so that the bars, when laid up in the furnace, will be separated by an air space equal to the air space in the bar. This air space is maintained by casting lugs on the sides of the bars to space them properly in the furnace.

The usual air spaces allowed between the fingers of the bars are 3/16 inch, 1/4 inch, 5/16 inch, 3/8 inch, 7/16 inch, 1/2 inch, 5/8 inch and 3/4 inch, the fingers and webs being usually about 1/2 inch wide on the top surface of the bar, and made with as much draught as possible.

It is highly desirable, and usually demanded, that all the bars in a furnace or set of furnaces should be uniform in size and interchangeable. This, of course, very much reduces the number of spare bars which must be carried, permits the shifting of bars to the hotter portions of the fire, as they burn out, and allows all the bars of a set being cast from a single pattern.

The width of the furnace is made up of the standard 6-inch widths of bar, if in a multiple of 6 inches, otherwise this is usually made up by the use of one or at most two bars of odd widths.

Patterns are usually carried 3 inches, 4 inches and 5 inches wide, narrower spaces being filled in by single bars.

The length of the furnace is made up by varying the length of the bars as required, the patterns being made from 24 inches, or even shorter, to 6 feet long.

On account of the considerable difficulty of running the long bars in the foundry, and the distortion which is apt to

occur in the pattern and through shrinkage in the casting, as well as that due to unequal heating in the furnace, the writer would give preference to bars in the neighborhood of 36 inches to 42 inches long.

Even with bars of a standard width, a very great number of patterns are required in order to cover the full line of air spaces, lengths and type, except in the case of furnaces furnished as part of a standard equipment, as, for instance, in locomotive boilers and boilers of a similar type. It has, therefore, been usual to make up the pattern equipment in wood patterns.

Where standard bars are possible, these are best made up of metal, preferably aluminum, and mounted on a molding machine of the roll-over type.

On account of the extreme delicacy of the slender green sand cores forming the air spaces in the bars, it is highly desirable to keep the pattern as light as possible, so that the molder, in drawing it, will be able to tell, by the sense of touch, where the cores are sticking.

It is the writer's opinion that in the long run the shorter-lived wooden pattern will, on this account, give better results in the foundry if hand-molded.

The Tupper bars referred to consist of side webs, connected by heavier portions at the ends, and filled in by fingers running at 45 degrees to the length of the bar, in opposite directions, on the two sides of the center line, meeting at right angles in the middle of the bar.

The Adams bar is a slight variation of this arrangement, in which the fingers, instead of meeting at right angles at the center of the bar, extend clear across from web to web at an angle of 45 degrees.

In making wood patterns for either type of bar, it is usual to finish up long strips to the proper cross-section for the fingers and then cut the fingers from these. A piece cut to the draught-angle of the finger, and fastened to the side of the trimmer, greatly facilitates the work of fitting the fingers into the bar.

These bar patterns are always built up by fastening the webs and end pieces to a plane board, and then fitting the fingers in.

The insides of the webs and the sides of the fingers must be

varnished and finished before the pattern is assembled, as it is impossible to properly finish these surfaces after the bar is assembled.

The greatest care should be taken in glueing the fingers to the webs, as the sand from the mold is bound to work into the joint if there is the least opening and spread the webs of the pattern apart, so that the resulting castings will be too wide, the cumulative error often amounting to more than the clearance allowed in the furnace, so that the set of bars cannot be put into the furnace. After a bar pattern has gotten into this condition, it is impossible to repair it without taking it apart, entailing nearly as much labor as the making of a complete new pattern.

A disc sander is very convenient for finishing the pattern after it is assembled, as the portions of which it is made have the grain running in several different directions, and it is difficult to plane the bar without breaking off some of the corners.

The sawdust bar referred to consists essentially of a plain plate supported by ribs, the plate being pierced by round holes. The pattern is much simpler in construction than the pattern for the Tupper or Adams type, the round holes being drilled and tapered for draught by means of a burning iron, which gives a smoother and better finish in the hole than a tapered reamer would.

Circular grates, for use in vertical boilers, are divided into sections of such size that they will pass through the fire door. If these grates can conveniently be divided into an even number of sections, only half of the number of patterns will be required, as the castings can be reversed end for end in the furnace, thus making right and left pieces from the same pattern.

Where an odd number of sections is necessary, an extra pattern for the middle section is required.

The bearing rings on which these grates rest are also made in pieces of such size that the castings will pass through the fire door. These can always be divided into such parts that one pattern will make all the castings required.

Automobile Castings.

The successful making of automobile cylinders is generally conceded to be one of the most difficult branches of the art, both

on account of the intricacy of these comparatively light castings and the rigid inspection to which they are subjected.

E. T. Doddridge, pattern expert with the Osborn Manufacturing Company, of Cleveland, Ohio, was, for several years, in charge of the pattern equipment of the largest concern in the country engaged in the casting of automobile and gas engine cylinders.

The following is quoted from a letter written by him:

"In the first place, it is necessary to determine the method of making the casting to insure a clean and perfect one, true to the pattern. The usual practice and most successful on this class is making the casting on end, this being determined, however, by the style and general shape of the cylinder, as well as the convenience and safety in placing the cores and taking off the vents.

"Parting lines are usually determined for the easiest and surest way of placing the cores in the mold, and not, as in the case of most patterns, by the easiest way to make the mold. Any undercuts, facings and core prints can then be taken care of by running extra core prints to the parting line, in order to make the joint straight for ease in putting the pattern on the molding machine, as nearly all such patterns are now made on machines of one kind or another.

"Right here arises the question of the type of machine to use. As a general proposition, unless it is a four-barreled cylinder, having a part of the crank cases cast on, or an extra large one, which would require several bars in both cope and drag, it has been the writer's experience that a machine of the flask stripping type, or an ordinary stripping plate machine, gives the best results, both as to speed and accuracy, the preference being given to the flask stripping machine on account of the cheapness with which the pattern can be mounted, as well as the fact that when the pattern and plate are drawn, the flask pins come with the plate and the flask itself is clear of everything.

"Sometimes, however, it is preferable to make the drag on a roll-over machine, on account of not having to bar the drag flask, and the cope on a flask stripping machine. This method is usually the better one when the pattern used is a cylinder of the larger type and made in green sand. The core boxes should be carefully considered, not with the idea of making as few cores as pos-

sible, but making the cores accurately, easily assembled and pasted, as well as placed in the mold with the least trouble, always bearing in mind, however, that a good, clean casting is the desired end.

"The question of flasks is also very important, and the possibility of making standard flasks, pins, plates, etc., for this kind of work is a great one, and a little thought along this line will save a firm considerable money in the course of a few months, as the flask expense is usually one which is quite an item.

"In making flasks for use on molding machines, accuracy in drilling the holes and fitting the pins is absolutely necessary, as well as having the flasks true on the joints. Poor results obtained from an otherwise perfect equipment will nearly always be traceable to imperfect flasks.

"The question of pattern equipment is one of prime importance, and usually a little time spent on a pattern, not merely to put a fine polish on it, but to make the pattern in such a way as to give the best results in foundry and core room, will pay many times over, especially on duplicate work such as this."

In considering crank cases and similar castings, so largely used in motor-car construction, we have an interesting opportunity to compare the diverse solutions of the same problem developed in different shops.

In a cast-iron sanitary ware shop the pattern for a piece of this type has been observed made up complete in metal, follow boarded, the whole mold being rammed up in green sand.

Similar practice has been observed in stove shops on similar pieces, but in view of more recent developments in this line, one would rather expect either a matchplate against one side of which the drag would be rammed, and the opposite side of which would form the cope or two mating matchplates, one for cope and one for drag, each backed with plaster or other composition for support.

In a motor-car shop we find the drag pattern (plane parting in this case) fastened to a board against which the drag is rammed, corresponding to the matchplate referred to above, but the cope instead of being rammed against a cope matchplate is rammed against a plane surface, the inner side of the casting being formed by a dry sand core hung from it.

The writer would not care to venture an opinion as to which of these three methods is the best, nor even to attempt the statement of a general rule which would define the circumstances under which any one should be given preference over the others. There are so many variables involved that each case must be decided on its own merits. In general, it will probably be conceded that either the follow-boarded pattern or the matchplate process would show a higher first cost for patterns than the dry sand core arrangement, and offer less opportunity for changes in the pattern than the latter.

Against the lower pattern cost we have the expense of making, drying, handling and setting the core. The follow-boarded pattern requires the handling of both follow board and pattern, cannot conveniently be handled on the molding machine and is more liable to damage than either of the other two.

The matchplate can be used with or without the machine. Whether made in one piece, or as a pair, it affords good protection to the pattern, the separate plate for cope and drag permitting the strongest possible support for the pattern surface. The latter construction often permits effective team work in the foundry, one man working on copes, the other on drags, and both together doing the lifting. This division of labor is practiced in both machine and hand-molding.

The dry sand core method is perhaps to be preferred to the others, where a fewer number of castings is required or where alterations may be necessary. Both pattern and core box can be made comparatively rigid of wood, and thus permit more rapid work in the pattern shop. The same division of labor in molding can be practiced with this equipment as with separate cope and drag matchplates.

Textile Machinery.

Textile machinery is older than machine tools, so that it is only natural to expect practices in this industry well developed and boiled down to high efficiency by the elimination of the unfit through years of experience.

Although this product is now machined and assembled by modern methods in the progressive establishments, the old days of laborious hand-work in fitting together pieces of such considerable

size as the side frames and cross girts of looms have left their mark in the comparatively high degree of accuracy and finish demanded in the castings.

The writer found at the plant of the Crompton & Knowles Loom Works in Philadelphia a very strong tendency toward attaining this end through the extensive use of molding machines, and the molding machine practice developed to a degree of efficiency and simplicity which has its lesson for the founder in any line.

Patterns for such large castings as the side frames and cross girts already referred to are made of wood, parted on a plane, wherever possible, in the usual way and molded on the floor with a follow board.

There are in addition a very large number of smaller parts which belong to the general run of small machine parts, and patterns for these are made very generally of wood. The number of castings from any one pattern going into a complete machine is not great, and as the machines are of considerable size, and made in a great variety of styles, the use of wood patterns needs no further comment. The same conditions control the methods of mounting the patterns.

The plant to which reference has been made has solved the latter problem by adhering to plane partings as far as it is possible to do so. Where bosses or lugs fall off the parting plane, cores are used in preference to an irregular parting.

The pattern boards are made of pine, thoroughly seasoned, but not as carefully selected with regard to knots or other blemishes as pattern lumber would be. These boards are found amply durable for the service required of them, and are so inexpensive that mounting of a large number of patterns, which are perhaps used only occasionally, is not a serious item.

The protection which the board gives the pattern, not only in the foundry, but in the pattern storage, is an item of considerable weight. Every molder knows that one of the most prolific causes of ragged molds from split wood patterns is the back draught resulting from the breaking and wearing away of the edges of the pattern adjacent to the joint, and every patternmaker knows that these edges are first watersoaked by the molder's sponge and then broken by kicking the patterns around the sand

pile. Patternmakers know, too, that no matter where rapping plates and draw plates are placed, the molder will find it necessary to drive his spike elsewhere. So the pattern board serves many useful purposes.

In storing patterns on boards it is only necessary to erect uprights, spaced according to the flask sizes and slide the boards in on ledges nailed to these. The uniformity thus secured simplifies the storage question wonderfully.

In mounting the patterns an ordinary mold in an ordinary flask is rammed up from the split wood pattern just as in making any casting. The mold is now separated with the corresponding half-patterns left in the half-molds, the drag board laid on the drag and the cope board laid on the cope, and both rolled over with the boards down.

By digging down into the sand it is easily possible to drive a couple of brads through the patterns into the boards, and after removing the boards to fasten the patterns to each where located, and the job is done. It is easily possible to mount an average pattern in this way in twenty minutes, and, therefore, not hard to believe the statement that it pays to mount patterns in this way for ten molds.

This interesting method exemplifies in a striking manner that the simple, sure way of proceeding by logical steps is in the end the most efficient.

Not a single piece of special equipment is required to do the job, and, while not a single measurement is made, the job is located with perfect accuracy because the pattern is located on the board by the mold exactly as the board must locate it in the mold later, and the board is located by the flask exactly as it must later locate the flask. A mistake is impossible.

There are, of course, jobs on which a plane parting cannot be secured even by the use of cores.

These are handled with almost equal simplicity by making an ordinary litharge and sand match rammed against a half-mold as usual. The cope plate to go with this is made by removing the pattern from this match and ramming another match against the first.

This latter will then be an exact mate of the parting surface already formed, bearing an exact duplicate of that portion of the pattern buried in the first match.

By fastening the pattern into the first match a pair of pattern plates for cope and drag is secured by a process just as simple and just as accurate as that described for plane partings. This process is thus applicable to patterns which are not split. Slender projections, which would not stand well in sand, can be made of wood or metal and rammed into the match.

Still another interesting feature is the making of hollow frames and similar shapes, in which the metal is so thin that it would be almost impossible to cast them with dry sand cores on account of shrinkage cracks, arising through failure of the core to crush.

Some of these are made from metal patterns in three-part molds, but a more original and ingenious way, due to Mr. McCleary, of the Crompton & Knowles Loom Works, consists in ramming the drag in a barred flask and then ramming up a green sand core in a box with ears exactly like those on the cope flask.

After having rammed the cope, and drawn the pattern, the drag is placed on the core box, the whole rolled back with the drag in its normal position, and the core box lifted off, leaving the green sand core in the mold. The mold is then closed in the ordinary way.

This clever expedient for avoiding the difficulty of setting a green sand core deserves a tribute to Yankee ingenuity.

The writer found in Mr. McCleary another enthusiastic advocate of the arrangement of patternmakers' work benches with their left ends toward the windows, the foreman's position being at the end of the line. With this arrangement some little clearance should be left between the wall and the left end of the bench, but wherever space will permit this clearance should not be occupied by the tool chest, as most of the shavings fall at the left end of the bench.

Mr. McCleary has provided a vertical tool cupboard over the right end of each bench, which all the men use, storing their own tool chests elsewhere. He has also installed a small bench trimmer at the right end of each bench—a wonderful time-saver.

Lathes, jointers, planers, trimmer, band saw and combination saw-table are provided, as is practically universal.

Paper Mill Machinery.

The parts of paper mill machinery, like most of machinery, naturally fall in two classifications—large and small. They are, however, unlike the parts of machine tools or engines, for instance, in that this machinery has to be built special to meet the particular circumstances obtaining in the plant where it is to be used.

There are, therefore, few standard parts which can be used on all machines, or parts of similar design which can be made in a range of sizes.

The completed machines are large and expensive, and a design once built is seldom duplicated in its entirety.

This condition naturally leads to the extensive use of wooden patterns, so made that bosses, pads and core prints can be conveniently moved to suit the varying conditions, and to make right- and left-hand castings from the same pattern.

A typical example of the larger castings used on this class of machinery is the housings, which are commonly made from wood patterns with flat backs rammed up on a plane board. The usual machine elements, such as handles, levers, cranks, gears and bearing caps can, to some extent, be used on different machines. Patterns for these are gated up in wood or metal, as the number of castings required may indicate.

At the plant of the Moore & White Company, Philadelphia, such parts as are used more or less frequently are made up either in wood or metal, and such as do not have plane partings are worked with hard sand matches. Most of these gates are made with lugs for screwing onto vibrator frames for the Tabor Power Ramming Machine. The patterns are stored in their matches and attached to the vibrator frames as needed in the foundry, one vibrator frame for each size flask only being used.

The casting of the rolls for paper machines is one interesting feature, characteristic of the manufacture of such machines. These roll castings must be absolutely sound, without surface defects, as finished castings having such defects would mar or tear the paper.

The rolls are used in considerable numbers and a great variety of sizes. On account of the requirements they are always cast on end, and wherever possible made with a considerable ex-

tension at the cope end, which acts as a riser and collects the dirt in the casting, being subsequently cut off.

The smaller sizes of rolls are cast from complete wooden patterns. Where special diameters of rolls are required, these are frequently made up by lagging the wood patterns and cutting out the sand to the lines indicated by the lagging in the mold.

Medium-size rolls are made by the Moore & White Company by a very ingenious method on a Tabor power ramming stripping plate machine.

Four patterns, each equal in length to the depth of the flask, are mounted on the machine. The flasks are then rammed up and stacked to the number required to make the desired length of roll, thus making all lengths of rolls of any one diameter from the one pattern, and permitting molds of a size very much in excess of the capacity of the machine to be built up.

The cores for the rolls are built up of hay rope and mud on an arbor.

The larger sizes of rolls are made from a short section of iron pattern, which is drawn up as the construction of the mold progresses. Cores for these, as well, are made up from hay rope and mud. The largest sizes are made in loam.

Another interesting process, observed in the plant of the Moore & White Company, is in connection with the construction of their speed-changing device, which consists of a pair of cones on which a belt is run. These cones are required in varying diameters and lengths, and in varying proportion of diameters, between large and small end.

This range is covered by a single set of patterns by making all the cones of the same angle and making up the patterns in sections, so that sections can be removed or added to either end of the pattern, thus forming the casting of a small cone from a pattern made up by using the smaller sections of pattern; a cone of larger diameter by dropping off the sections at the small end of the pattern and adding a section or sections at the large end; a long cone having a greater difference of diameter between its ends by adding sections at either or both ends.

The very large sizes of cones are not made in a single casting, but built up of sections forced onto the shaft. The various proportions of cones are built up in the same way as the cone

patterns for the smaller sizes; that is, by using larger or smaller sections.

Machine Tools.

Parts of machine tools consist essentially of large heavy pieces, such as beds, planer tables, housings, head and tail stocks, etc.; smaller pieces, such as chucks and face plates, carriages, etc., and still smaller pieces, such as cranks, levers, gears, pulleys, etc.

These castings are almost entirely molded in green sand from complete wood patterns, the number of pieces from any one pattern required seldom warranting the expense of permanent metal patterns, except in the case of some few gears, levers, cranks, cams and possibly bearing caps.

The patterns are seldom made adjustable or changeable, as designs for machine tools are made more or less standard and not varied for different orders, the machines being made up for stock, and the patterns changed only when new designs are made and a new stock lot is put through.

The wood patterns are, as far as possible, split on the plane of the parting, and such patterns are, therefore, well adapted to mounting on molding machines of the roll-over or jarring type, even where a comparatively small number of castings is required to fill an order.

Small pinion blanks and castings for bushings are frequently made from patterns which are long enough to make several of the finished pieces. These are cast on end with an additional length allowed in the cope, to act as a riser. The cope end of the casting is gripped by the chuck in the lathe when machining these castings and pieces are parted off as finished. The writer has seen this principle carried to large rings for internal gears up to 48 inches in diameter.

In making patterns for machine tools, it is well to consider the method by which the castings must subsequently be handled in the machine shop. Where pulleys or gear blanks are gripped in a three-jaw chuck for turning, it is always preferable to use three or six spokes, so that in holding the casting from the inside the chuck jaws will fall in the spaces between spokes, or in holding the casting from the outside the pressure of the chuck jaws will be applied opposite the spokes, thus preventing the distortion of

the rim. Particularly in the case of thin parts, such as rings, etc., it is advisable to cast lugs by which the castings may be bolted to the face plate, coring the lugs for this purpose, so that the castings may not be distorted by clamps or chuck jaws, which would otherwise be required to drive them.

As all of these castings require machining, and usually one side forms an important bearing, or is exposed to view in the finished product, it is often necessary to make the pattern so that it will mold with the machined surface down, to insure the soundness of this part of the casting, even where such a position entails additional expense in the pattern making and molding and core making.

Machined surfaces forming joints which are not sliding bearings are frequently as effective if recessed at the center and machined for bearing at the edges only, and this should be done wherever possible, particularly if the castings are to be milled, as the recess breaks up the chips and permits much heavier cuts and feeds being taken.

If castings are to be finished by disc grinding, the finish should be as small as possible, and the surface broken up by recesses or grooves, to reduce the heating and provide spaces for the material ground away to get from the surface being ground.

Where castings are to be turned, planed or milled, the finish should not be less than ⅛ inch, so that the point of the cutter will get below the scale and lift the scale off rather than cut through it. It is frequently easier to remove ⅛ inch, with the point of the cutter constantly under the scale, than to remove less metal when the cutter hits the scale at low points.

Where machining is required at the ends of a casting of any considerable length, or at the sides or top of castings which are apt to spring out of line during cooling, extra finish should be allowed to take care of this contingency. Extra finish on the cope side, to take care of dirt and gas holes, is usually advisable and much cheaper in the long run than the rejection of an otherwise perfect casting on account of such defects.

Chuck bodies and face plates, when made with dry sand cores inside, are apt to come oversize in the casting, as the core will not crush sufficiently to allow the casting to take its full shrinkage. Suitable provision should be made in the size of the pattern where this occurs.

Castings for Engines.

Castings for engines, as far as shape, number required from a pattern and sizes, compare very closely with castings for machine tools.

The patterns are made up in practically the same way. These castings may be roughly subdivided into castings for internal combustion engines and castings for steam engines, and this general classification may be made to include, as well, castings for pumps and air compressors.

Probably the most difficult castings of this general class are the cylinders, which must be absolutely sound in the bore, and are usually made close grain and comparatively hard, to provide for wear, as well as against leakage.

Cylinders for air compressors are frequently water-jacketed, cylinders for steam engines steam-jacketed, and cylinders for gas engines water-jacketed or provided with heat-radiating ribs.

The cores for such jacketing, as well as the port cores, in addition to the main core forming the bore, complicate the work on the patterns and core boxes and in the foundry.

The general practice is to make the main core for the bore separate, and to assemble the port and jacket cores around them, these latter cores being located, with reference to the main core, by means of prints, as far as possible, though the use of anchors and chaplets is frequently necessary.

The beds, which are the largest castings going into the construction of the engines, are made usually in the same way as beds for machine tools.

The fly-wheels for small internal combustion engines, particularly, are now being very extensively made on the various types of molding machines.

Large engines require a variety of fly-wheels, often combining band-wheels for driving belts or gear-wheels with the fly-wheel. For this reason the larger sizes are often swept up in loam or built up in cores. This method of building up the mold, using a segmental rim pattern only and a core box containing a half-arm, makes it possible to turn out castings of a size considerably beyond the capacity of the woodworking tools in the pattern shop.

Chain Sprockets.

The requirements of the Link Belt Engineering Company have been selected as a good example of a pattern equipment for this line of work, where a great variety of different sized pieces, all of practically the same design, is required.

Their pattern equipment illustrates in a striking manner how standard pattern elements can be combined to meet the different requirements for castings and also where such combinations cannot be made to advantage.

The sprocket patterns for the Ewart chain, which is the ordinary malleable cast link chain, sometimes referred to as chain belting, are made up complete in iron, as far as the teeth, rims and spokes are concerned. The spokes meet in a web at the center of the wheel, all wheels being bored at the center for a 1-inch dowel.

All hub patterns are furnished with a 1-inch dowel pin, so that any hub can be used on any wheel pattern.

The wheel patterns vary in diameter, in number of teeth and pitch of teeth.

The hubs are made to correspond to the diameter of the shaft on which they are to be used, the different pitches of chain and specifications for set-screws or keys.

Set-screws and keys make it necessary to vary the amount of metal allowed in the hub for any particular size of bore. Thus a sprocket of a given diameter and given bore would have a heavier hub for a large pitch chain than for a small pitch chain, and a still heavier hub if key-way is requried.

None of these patterns are mounted for molding machine use, as it would not be possible to make up a stock of castings in advance, there being so many variables involved.

If a stock of castings, for instance, were made up for any given pitch and number of teeth, the hubs might not be of the right size, or, if the hub and pitch were right, the number of teeth might not be what was required.

A slight variation from these patterns is in those made for what is known as the "flint rim" sprocket, in which case the pattern does not have the teeth, but a print around the edge, which receives the chill for chilling the teeth and rim.

This company has its patterns for cast tooth spur and bevel gears made up in the same way.

All the gear and sprocket patterns take two kinds of interchangeable hubs, the one for a solid wheel, the other for a split wheel, the split wheel hub pattern having prints for splitting cores and also for cores for the bolts by which the hub is bolted together. Where a wheel is made with the split hub, two lugs carrying a splitting core print and bolting core prints are fitted to the rim.

In such cases, as wooden patterns for tooth gears are used, the teeth are not dovetailed into the rim, but their position is indicated by center lines on the rim and on each individual tooth, the teeth being held in place by corrugated sheet metal fasteners driven half into the tooth and half into the rim. This makes a very much cheaper pattern than dovetailed teeth, and it has been the experience of the Link Belt Company that patterns so made are very satisfactory in service.

The usual finish allowance on the ends of the hubs for iron castings is 3/16 inch each end, 5/16 inch is allowed for finish in diameter of bore for hubs bored up to 2 15/16 inches diameter. For hubs bored larger than 2 15/16 inches, and up to 4 15/16 inches, a 3/8-inch finish is allowed in the diameter, and for hubs bored larger than 4 15/16 inches, a 1/2-inch finish is allowed in the diameter.

In wheels to be cast in steel, the finish allowance in the bore is never less than 1/2 inch in diameter, and up to 2 inches bore the cores are omitted entirely.

Large diameter sheave wheels for rope drives are made from complete wood patterns, using a dry sand core for the groove in the rim wherever there is but a single groove. Where multiple grooves are required, it is more usual to sweep the rim, using a hub pattern or hub core box and a core box containing a half-arm, two cores being used to make each arm, and the hub and arm cores assembled in the mold after the rim has been swept up.

Spools for cable hauls, which have a neck in the center smaller in diameter than the ends, are made by parting the pattern in the center and molding in a three-part flask, the center line of the casting being vertical in the mold.

A rather unusual casting made by the Link Belt Company,

for its coal-handling equipment, is the screw conveyor flight casting, consisting of a hub with part of a helix attached. As the helical portion of this pattern would not draw directly from the sand, the hub is made hollow in the pattern and the helix attached to it by thumbscrews from the inside.

When drawing the pattern from the mold, the thumbscrews are removed and the helical portion of the pattern is screwed out of the mold.

Another rather unusual casting is the drum for the coal crusher. These drums are made from solid cylindrical patterns, which, in effect, consist of a print for the chills, which form the outside of the drum and prints for the cores which hollow out the inside of the casting. The chills form the teeth on the outside of the drum, and are set in the impression left in the mold after withdrawing the pattern.

Manufacture of Cast-iron Pipe.

In the manufacture of cast-iron pipe repetition process is carried perhaps further than in any other foundry operation. The development of this special line has been carried so far that it is impossible to describe the patterns without going into the molding process as well.

Of the several methods by which cast-iron pipe is molded, the one in use by the Standard Cast-iron Pipe and Foundry Company, at its Bristol foundry, will be described.

The patterns are divided into three principal parts, the lower portion of the pattern, which forms the bell end of the pipe, being attached to the base of the molding machine.

The long cylindrical portion of the pipe is formed by the pattern attached to the ram of the molding machine and the spigot portion of the pattern used separately, as will be described later.

The bell portion of the pattern referred to consists of a revolving head, carrying three or more blades, the extreme outer edges of which have the contour of the desired bell end of the casting.

The blades carry essentially the same contour as they swing in toward the center of the head, being held in somewhat the same position as the blades in a fan blower.

In the center of this head is a socket, having driving lugs on

its interior. That portion of the pattern forming the cylindrical part of the pipe consists of an iron bar of about the same length as the pipe casting, carrying a flange at its upper end, by means of which it is bolted to the ram of the molding machine and a projection at its lower end provided with driving lugs, which projection fits into the socket of the head.

In operation, the flask is set down on the base of the machine and clamped to it. The ram of the machine with its attached pattern is then lowered into the flask, the projection of the pattern fitting into the socket in the head, the driving lugs engaging with each other.

A hopper or funnel having been placed around the top of the flask, the sand is shoveled in until the flask is full and the arm of the machine rotated. The shape of the blades on the head or bell pattern presses out the sand which falls between the blades and forms the mold for the bell end of the pipe.

The cylindrical portion of the pattern has on it a hard cast-iron strip, and immediately behind this strip is a channel into which the sand falls. As the arm is rotated the cast-iron strip on the side of the pattern presses back into the mold the sand which lies around it and in the channel, and as the arm is withdrawn from the flask and rotated at the same time, a hardened cast-iron cone at the lower end of the pattern is forcibly drawn through the sand of the mold, thus completing the ramming and determining the size of the mold cavity.

This process is, in many ways, quite the opposite of ordinary foundry processes, as the ramming is accomplished by the pattern itself by making it of a shape which in ordinary foundry practice would be called "back draughted."

The mold so rammed is in many ways ideal, as the sand is compressed most at that portion of the mold which will be adjacent to the casting and of decreasing density toward the outside of the flask, thus accomplishing ideal venting of the mold.

After the mold has been rammed as above described, it is removed from the machine, and while suspended from the crane the bell portion is dressed by hand as may be required.

The bottom plate of the flask is provided with a circular opening, which locates the bell core, and with dowel pins matching dowel holes in the base of the flask and located exactly as are the dowel pins in the base of the molding machine.

The bell core is made on a cast-iron spider, having at its lower end a projection fitting the hole in the bottom plate by which it is located, and at its upper end a depression into which the main core fits and by which the latter is located. The bottom plate also has in it an annular depression filled with sand, against which the end of the bell is cast. After having placed the bell core, the bottom plate is attached to the flask and the flask swung over to the position where the spigot is molded.

To mold the spigot, a short portion of pattern, slightly less in diameter than the mold, is entered into the top of the mold, and the iron spigot pattern, which fits over this short portion of cylindrical pattern, and is provided with two handles, is forced down into the sand at the top of the mold, thus forming the mold for the spigot end of the pipe.

The cores are, of course, not made in boxes, but on arbors wound with hay, straw or hay rope, and covered with mud while they revolve on the core-forming machine, the shape being determined by a hard steel strip mounted on the machine. After the first coat of mud has been applied, the cores are dried and subsequently are coated a second time and blacked.

The lower end of the core has a tapered portion fitting the tapered hole in the top of the bell core spider referred to above, thus centering the core.

Separate patterns are provided for the various diameters of pipe required, and to some extent for the various thicknesses of pipe, as well, though the thickness is also occasionally varied by using the same pattern, but reducing the diameter of the core.

Specials in the way of connections, etc., are cast according to their size, specifications and numbers required, either in green sand from complete wood patterns, in dry sand or in loam, the dry sand castings being ordinarily made from patterns and the loam castings from sweeps.

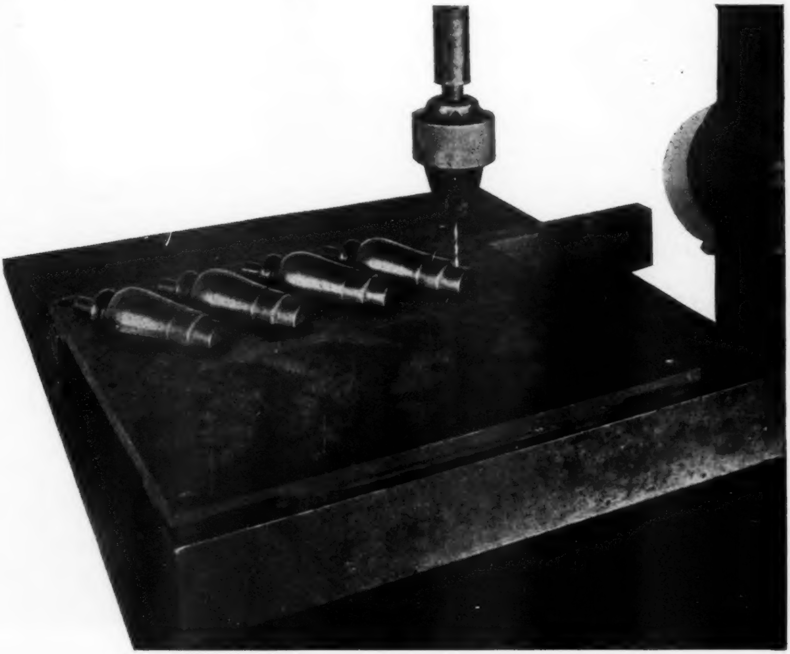
The cores for specials, as well as for the pipe, are frequently made with hay or straw and mud, though they are sometimes made in the ordinary way, according to their shape and size.

These latter patterns are made by ordinary pattern-making processes.

The standard patterns for pipe, however, are practically a machine shop proposition, as they are really a portion of the molding machine.

VALVES.

The manufacture of valves would seem to offer an almost ideal field for machine molding, not only on account of the comparatively large number of castings of one kind, particularly in the smaller sizes of standard types, but also on account of the symmetry of the designs.



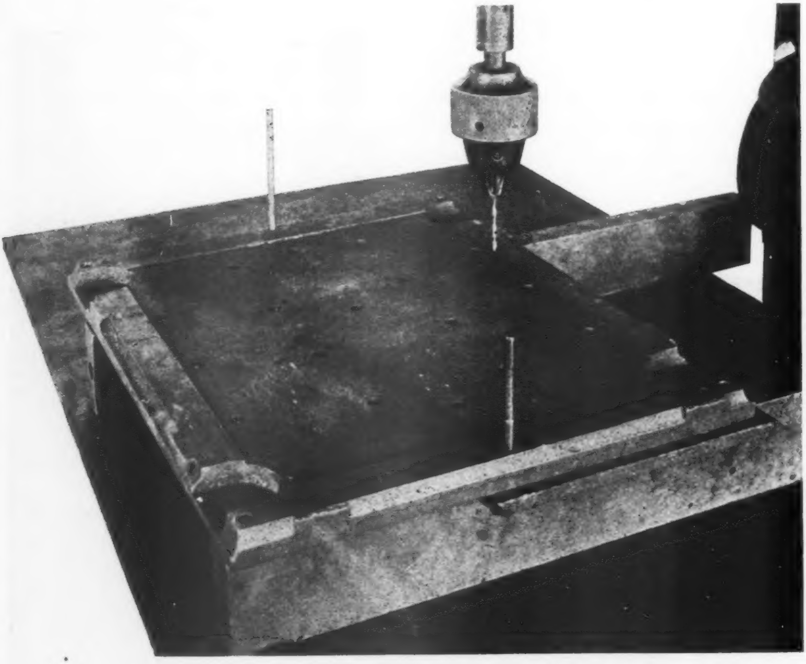
Courtesy of The Tabor Mfg. Co., Philadelphia.

FIG. 1.—DRILLING PATTERN PLATE FROM PATTERNS.
(NOTE NUMBERS STAMPED ON PATTERNS.)

The great majority of valve parts are symmetrical about a plane, and are, therefore, perfectly adapted to mounting on flat plates for squeezer machines where the same plate makes both cope and drag. This arrangement involves but half the pattern equipment and half the number of pattern changes on the ma-

chines required where two plates are necessary, and when machines are not run in pairs, permits the closing of the molds as rapidly as they are made.

Many of the small parts which are not symmetrical about a plane can still be made with a plane parting and on a single



Courtesy of The Tabor Mfg. Co., Philadelphia.

FIG. 2.—DRILLING TRANSFER PLATE FROM PATTERN PLATE.
(NOTE PINS LOCATING PLATES WITH REFERENCE TO EACH OTHER. PATTERN PLATE IS ABOVE, TRANSFER PLATE BELOW.)

plate by mounting opposite halves of the pattern in such a position that they will come in the proper relation in the mold.

This is accomplished by the well-known transfer plate process, briefly described below:

Assuming a plane parting, half as many split patterns as

there will be castings in the mold are made up, the mating halves being marked for identification.

The planed pattern plate is drilled for the flask pin holes by means of the standard drill jig.

Courtesy of The Tabor Mfg. Co., Philadelphia.

FIG. 3.—TURNING THE TRANSFER PLATE.
(NOTE THAT PLATE IS TURNED AS DRAG WOULD BE—NOT END FOR END.)

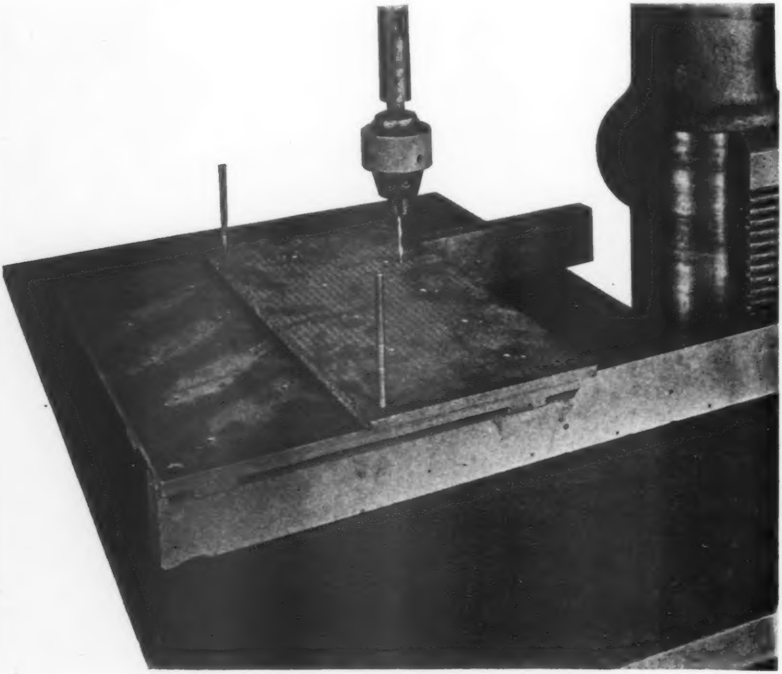
Each pattern is carefully matched up and has two small holes drilled entirely through both halves.

A plate a little more than half the width of the pattern plate is now prepared either with two holes matching the flask pin holes or two other holes on the center line between the centers of

the flask pin holes. If the latter is the case, then corresponding holes must be drilled in the pattern plate.

This transfer plate is then laid on the pattern plate and doweled to it by the holes already referred to.

One-half of each of the patterns is now arranged on the



Courtesy of The Tabor Mfg. Co., Philadelphia.

FIG. 4.—DRILLING SECOND SIDE OF PATTERN PLATE.
(NOTE LOCATING PINS—TRANSFER PLATE ACTING AS JIG.)

transfer plate and holes are drilled, passing the drill through the holes already in the pattern, through the transfer plate and through the pattern plate.

The transfer plate is then turned over exactly as the drag flask will be turned over in molding the job and located by its

dowels. The other side of the pattern plate is now drilled, using the transfer plate as a jig.

The half-patterns used in drilling the plates are now replaced on the plate, and the mating halves as indicated by the marks, placed on the other side of the plate, 'ocated by driving snugly

Courtesy of The Tabor Mfg. Co., Philadelphia.

FIG. 5.—PATTERN PLATE READY FOR PATTERNS, GATES AND RUNNER.

fitting rod through the drilled holes and screwed to the plates. The pattern halves must be turned just as the transfer plates were; that is, supposing a pattern to have a core print on one side of it, and this core print to be turned toward the runner in one half pattern, then the core print must also be turned toward the runner in the other half of the same pattern.

If the drilling has been done substantially at right angles to the plane of the pattern plate, and if the dowels and rod used have been a snug fit in the drilled holes, the match will be perfect; provided, of course, that the flask pins and holes fit each other and those on the plate.

Courtesy of The Tabor Mfg. Co., Philadelphia.

FIG. 6.—PATTERNS, GATES AND RUNNER MOUNTED ON PATTERN PLATE.

The plates are usually of iron, the patterns of iron, brass or alloy.

Gates and runners, with feeding or shrinkage bosses, when necessary, are made of brass or white metal and attached to the plates, as are also vents for the cores.

This same practice holds good up to the point where a single

half-pattern is mounted on a plate making both cope and drag of a symmetrical casting, one in a mold.

Still larger patterns are made in wood and mounted on wood boards for the jarring machine.

The largest castings, such as large valve bodies, are made by hand from split wood patterns, and very large or special bodies occasionally from skeleton patterns.

The practice is to turn in the lathe, or otherwise accurately machine, every part that can possibly be machined, and to do this the master patterns may be divided into elements, each turned separately, and then the whole assembled into the complete pattern. This method also frequently obviates the trouble of working out difficult intersections.

Wood patterns and core boxes are made interchangeable for flanged, screw and bell and spigot connections, but it is more usual, when making metal patterns and core boxes to make the master patterns interchangeable for the different types of connections, but to make separate metal patterns and core boxes for each type. Specials, such as by-passes, are made by attaching pieces to the standard patterns.

While the patterns for valves are comparatively simple, the cores are complicated and difficult in the extreme.

It is, therefore, natural to expect that many interesting methods applicable to difficult cores in other castings than valve parts have been developed.

At the plant of the Nelson Valve Company at Chestnut Hill, Philadelphia, it is the practice to separate these difficult cores into elements, which not only facilitates the making of the core, but also the making of the box.

As in the case of patterns, the box is so divided into elements that all surfaces which it is possible to machine are so formed, hand-work being confined to such irregular surfaces as the insides of the body.

On the smaller cores, particularly, it is the practice to make wood models of the cores, which is much easier to do and more accurate than working out the boxes for the cores. These wood models, with proper finish allowance for finishing up the box, are attached to boards, oiled, and plaster casts made from them. These plaster casts, when sufficiently set, are worked down at the

back to proper thickness of metal, due provision for rapping bosses, pins and pin hole bosses being left. This work is greatly facilitated by band sawing the plaster cast to approximately the desired outline and working it down by hand.

The iron castings obtained from these plaster patterns require very little work to complete the core box, except that in the openings for pipe connections and seats, they are carefully turned out on a lathe to insure the minimum of work in finishing the valve.

The larger core boxes, particularly in cases where new designs are being developed, are first made in wood in the usual manner, advantage being taken again of the sectional element construction, the elements being shaped separately and assembled.

The iron boxes are subsequently made from these wood boxes by a very ingenious process, as follows:

For the smaller core boxes a frame is made, the outside dimensions of which correspond to the outside dimensions of the wooden box, and inside this frame is placed a pattern of the same shape as the outside of the desired iron box. The wooden box is prepared for molding by pasting paper or other material for finish allowance on the joint surface and on other surfaces which are to be machined in the iron box.

The wood box is then rammed up in a sand mold, as though it were a pattern, the inside of the box forming that portion of the mold which will form the inside of the iron box, the outside of the wooden box being practically a core print in this case.

A dry sand core is made from the wooden frame containing the pattern of the desired shape of the outside of the iron box, already referred to, and this dry sand core set in the impression in the mold left by the outside of the wooden box. Castings made in this way accurately and cheaply reproduce the shape of the wooden box in the desired iron form.

In the case of larger boxes, which it is desired to make of iron, the process is essentially similar except that in this case the pattern for the outside of the iron box is not made complete, but made in skeleton and set into the frame as referred to above, the shape being formed in the core sand by strickles.

The chief difficulty in making valve cores arises from the diaphragms passing through the bodies of the cores and the col-

lars and projections on these cores, resulting from the raised seats and the tap clearances necessary.

The diaphragms are almost universally handled by making them in the shape of loose pieces in the half-boxes. The half-cores with these loose pieces in place are rammed separately, struck off on the joint surface and the loose pieces withdrawn, after which paste is applied to the joint, the box assembled, rapped and drawn from the core.

Raised seats may be handled in the same way; that is, as loose pieces in the half-boxes, which are withdrawn before placing the half-cores together. These seats can sometimes be made to draw directly from the half-core boxes, but usually must be rolled out.

Another expedient in making difficult valve cores is a loose piece fitting each half-box, to which are attached core prints. Separate dry sand cores are made and baked and dropped into the impressions left by these loose pieces, when the latter are withdrawn from the half-cores.

In this case also paste is applied, after setting the inner core in the outer core, the box assembled and withdrawn, leaving the core on the dryer with the inner core in place.

Still a third method is to divide the core up into such parts as can be separately made in boxes, either with or without loose pieces, drying these core elements separately and assembling them afterward.

This process requires extremely careful work in the core-making to insure the parts of the assembled core being in proper alignment with each other. As far as possible, these core elements, which form openings in the valve which must be tapped in line with each other, are made in a single piece, to insure the tapped openings being in line in the finished valve.

Where it is not possible to carry a core element entirely through from side to side of the casting, the two ends may be located in the body core by means of long tapered prints.

These prints may either take the form of holes in the body core, corresponding to projections on the cores for the pipe openings or of projections on the body core, over which are placed cores in the shape of sleeves, which form the opening to be tapped in the casting and the tap clearance.

Globe valve cores are made in two parts, which are connected to each other through the hole in the seat. This is accomplished by providing a tapered square plug on one portion of the core and a corresponding tapered square hole on the other portion of the core. The taper is used for convenience in entering and to insure a tight fit after entering. The square is used to prevent the rotation of one core-half with reference to the other half, such rotation resulting in the openings at opposite ends of the valve being out of alignment.

It is needless to say that the core boxes for making these cores must be made with extreme accuracy.

Pipe Fittings.

The casting of pipe fittings in the more largely used sizes, say from ¼ inch to 12 inches, compares in many ways with the casting of valve parts of corresponding sizes.

The fittings are ordinarily made of cast iron, malleable cast iron and brass, and marketed plain or galvanized in iron, and rough or finished or finished and nickel-plated in brass.

Like valve bodies, they must be furnished flanged, threaded or bell and spigot for pipe connections, and with external and internal threads at opposite ends designated as street or service fittings, and with unions for close quarters, as in radiator fittings.

The fittings must also be furnished in various weights, according to the service for which they are intended. Drainage fittings not being subjected to pressure can be made comparatively light.

Cast-iron fittings for water, steam and gas are usually cast with a heavy square-edged reinforcing collar around the threaded ends. Similar patterns may be used for making extra heavy malleable or brass fittings.

Malleable fittings are made plain for gas, and with a half-round bead surrounding the threaded ends for steam.

The brass fittings are perhaps most frequently furnished beaded, similar to malleable fittings.

The use of steel castings for high-pressure superheated steam fittings is a somewhat more recent demand, and the writer has been unable to learn of the regular manufacture for stock of such fittings. These are made with flanged ends.

Without further attempt to list and classify the great variety of sizes and forms in which fittings must be furnished, it will be apparent from the nature of the business that the pattern equipment must be developed in line with the lowest molding cost possible on repetition work, and that the pattern-making methods must of necessity have become standardized through the constant reproduction of the same elements of construction in varying combinations and sizes.

The gated metal pattern worked in a hard sand match was always heavy, owing to the considerable size of the cores. The gates were frequently sprung and the patterns broken off, due to the weight. These difficulties early led to such arrangements of castings in the mold as would permit the core prints to be solidly fastened to each other, rigidly bracing the gate without disfiguring the castings. It was also found that the making, handling and setting of cores, and the location of cores in the castings was materially facilitated by thus joining the prints, and in many cases allowing a single core to serve for more than one casting.

Plane partings and symmetrical designs make of this an ideal molding machine proposition, and we find the split pattern equipment on squeezer machines very generally used.

The half-patterns are mounted on flat, iron plates, in much the same arrangement as when gated for hand-molding, either separate cope and drag plates or reversible plates forming both cope and drag or plates carrying cope half-patterns on one side and drag half-patterns on the opposite side being used.

The vents for the cores are best permanently attached to the plates, thus not only saving the time of scratching them in each mold, but insuring against the forgetfulness of the operator. The cores must be porous and well vented, as they are nearly surrounded by the metal, and even a tiny blowhole is sufficient to cause rejection of the casting.

The gates and runners are also permanently attached to the plate, and their form and position is vitally important, more so in the case of malleable fittings than in cast iron, on account of the greater sluggishness and higher shrinkage in weak parts of the metal. Improper gating, which carries dirt into the casting or creates excessive shrinkage in weak parts of the casting, is the cause of many rejections.

In gating malleable patterns the preferred practice is to come into the end of the casting alongside the core, placing the gate in the drag, and the runner always in the cope. By this means a static pressure head between the runner and the gate is maintained in the mold, and the iron is drawn into the casting from the underside of the runner. Shrink balls, extending up into the cope, are frequently built on the runner. They are usually put at the ends of the runner and serve the double purpose of feeding the shrinkage and catching dirt.

The process of making and gating the pattern for a ¾-inch ell is thus briefly outlined by H. F. Giele, of the Grabler Manufacturing Company, of Cleveland, Ohio.

"The casting will weigh about 8 ounces in malleable iron, and we find that a flask measuring 12 inches by 18 inches, which is a good, workable bench snap flask size, will be large enough for 16 pieces or 8 pounds, and 100 molds or 800 pounds of castings a good day's work on the bench.

"On a Tabor squeezer we get about 140 molds or 1120 pounds of castings per day, pouring two heats.

"Having thus determined the size of flask which will give the greatest number of pounds of good castings per day in the foundry, the pattern is mounted accordingly.

"The master pattern is made with double shrinkage in pine, and in halves.

"This is done as far as possible by machine, the curved portion of the ell, for instance, being cut from a half-round ring turned on the face plate and the ends, beads and core prints being turned separately.

"The inside of the master pattern is cut out, to lighten the castings for the working patterns; these are cast and then finished in pairs, again using machine work as far as possible."

The mounting of the patterns on the plate will not be repeated here.

"The core box is made of cast iron, first making (with proper shrinkage allowance) a pine model of the core, sometimes called a core stick, by the same methods as used for making the master pattern. Half of this core stick is fastened to a smooth board and coated with tallow and plumbago. A plaster cast is taken, trimmed to the desired outside shape and the core box castings made from it."

The above is quoted to show how closely analogous to valve practice the process is.

The number of pieces to be put in a flask is always a nice question as between the flask so small that enough molds cannot be made to give a reasonable weight of castings per day and a flask so large that output is restricted by the fatigue resulting from handling the heavy weight.

Usual sizes are 10 inches by 16 inches, 10 inches by 18 inches, 12 inches by 15 inches, 12 inches by 16 inches, 12 inches by 18 inches, 14 inches by 16 inches, etc., 14 inches being about as wide and 28 inches about as long as can be handled.

Aluminum matchplates, made in one piece from gated patterns by any of the well-known processes, can also be used to advantage.

Cast-iron Sanitary Ware.

The writer feels that he could not do better than refer you to the admirable series of articles on enameled cast-iron sanitary ware by Dillon Underhill, appearing in *The Foundry*, March, 1909, to June, 1910. These articles describe in detail the characteristics of the pattern equipment for producing this line and the methods employed in making the patterns.

Reference to these articles will indicate certain points of similarity between this and the stove industry.

Some of the thin curved sections required are perhaps even more difficult than those found in stove work. The method of building these up of sheet lead over a wood model of the inside of the desired shape, the casting of secondary master patterns from these, and the final working patterns from the secondary masters, has its lesson for the foundryman in other lines.

Another lesson which, in the writer's opinion is worthy of frequent repetition, is the standardization of pattern elements as exemplified by the lead master patterns sawed apart and extended to make other sizes of uniform design, and in the use of standard bosses and pipe connections which are made up in quantity from a single pattern and soldered to the various master patterns as required, thus maintaining interchangeability in the product, as well as materially reducing the expense of making the patterns.

Manufacture of Open Feed Water Heaters.

The manufacture of open feed water heaters involves essentially the construction of cast-iron boxes of various sizes, with openings for pipe connections and doors which provide for access to the interior.

The wide variation in conditions, applying in different steam plants, both as to size and character of the piping and number of sources of supply for steam and water, as well as provision for drawing steam and water from the heater, make it necessary to provide a great many special features on otherwise standard construction, as well as making necessary the construction of similar right- and left-hand heaters according to the peculiarities of the installation.

The smallest sizes are cast in a single piece, with the exception of the top. These are cast by the Harrison Safety Boiler Works, Philadelphia, on their side, the parting being on one of the outside faces of the box. The bottom is pitched for drainage and provided with lugs to which the pipe legs are attached.

The whole bottom, with its attached lugs, is made loose on the pattern, and all the pieces for the openings are also made loose on the pattern. The screws which hold these loose pieces to the pattern are taken out as the ramming progresses, and when the ramming is complete, the main pattern is withdrawn and the bottom and bosses are drawn back into the mold. This construction makes it very easy to transfer the bosses to one side or the other of the pattern, thus making right- and left-hand heaters from the same pattern, and also to provide special bosses and bosses of other than standard sizes.

The interior of the casting is formed by a dry sand core rammed in a box, the projections on the inside of the casting for supporting the interior parts of the heater being made loose in the box and drawn out of the core after the box has been removed from it.

The core is supported by a print coming out of the top opening of the heater, and also by prints extending through the door openings in the sides of the heater, the heater being cast in such a position that these door openings come on the bottom, thus carrying the weight of the core.

The flask is cut away at the end to facilitate the removal of

the interior of the core, which is filled with coke, so that the core will crush before the casting cracks, by reason of shrinking on the core.

Larger sizes of heaters are built up of separate plate patterns, these plates being made up of wood and molded by ramming up on a board in the usual way. These larger plate patterns must be strengthened by ribs, and the various bosses required are attached to the pattern where needed, each boss usually carrying its own core print, the openings being made with dry sand cores, so that the pattern will not be cut up for the various changes. The bosses are in every case cut over the ribs, rather than through the ribs, for the same reason.

If these bosses and openings are of standard sizes, this method affords a good illustration of the relative economy of making openings in this way, even though it might be entirely possible to mold them in green sand.

The attachment of separators, for removing the oil from exhaust steam which goes to the heater, involves the casting of a considerable number of bolting flanges, which must be raised from the surface of the plate to allow clearance for the nuts between the flange and the plate. This undercut is handled with dry sand cores, rather than making the flanges loose and drawing them back in the mold, as a pattern so made would be rather weaker and less durable, and there would always be a tendency for the loose flanges to be displaced during the progress of the ramming, thus resulting in castings which cannot be machined to the proper shape.

Steam and Oil Separators.

The making of castings for steam and oil separators involves a large amount of difficult core work, and the core boxes for this line are more interesting than the patterns.

Separator heads resemble in shape a pipe tee with an enlarged body, and are always made with flange connections.

One of the most serious difficulties is the baffle in the interior of the head, which cuts the core in two, except at the steam ports. Wherever possible, these cores are made in boxes with the baffle loose on the top or open side of the box, same being removed before the core is turned over onto a plate. These cores must

be supported by crabs, and as it would be impossible to get the crabs out of the castings after they are made without breaking them, these crabs are cast in open sand.

One method of making the separator cores is to make them in halves and bolt the halves together, thus securely holding them to each other and preventing any variation in the thickness of the baffle or side wall of the casting by shifting of the core. A bolt then passes through the baffle in the casting and is cut off at each side.

The flasks are so made that the core prints will pass through the sides, the flask being located on the pattern by the fit between the opening in the flask and the core print on the pattern, and the core subsequently located in the mold by the fit between its print and the opening in the flask, thus not placing dependence on the green sand support of the mold for locating the core.

Cores which cannot be made in this way are made by casting the baffle separate, ramming it up in the core and casting it into the head.

The patterns for these separator heads are symmetrical and are parted on a plane passing through the center line of the openings, thus making them ideal for mounting on the molding machine. In this case, all the undercuts between the flanges and the bodies can be drawn in green sand.

In the wells for separators, however, and in vertical separators, it is often desirable to make the castings in a vertical position, in which case the undercut between the body and the flange will not draw in green sand. This difficulty is taken care of in the small sizes by means of a dry sand core, which carries the flange. In sizes a little larger the flange is made loose, the flange pattern being bored to fit the core print. The castings are molded by drawing the flange back out of the drag before rolling over and using a cover core.

In some of the larger sizes, where the cover cores would be too large to handle, the flanges are made in segments and drawn back into the mold.

In those patterns which are mounted for molding on the jarring machine, the flange is taken care of by a very large core print on the pattern, which is drawn back from the drag before rolling over, the flange being formed by the core which fits this print.

Owing to the greater rigidity of the dry sand core, as compared with green sand, and the relative ease with which these dry sand cores can be blackened and vented, and also on account of the more rigid pattern construction possible, dry sand cores are very extensively used in making this line of work, the cores, as well as the mold, being rammed on the jarring machine wherever possible.

Smaller parts are made from wood or iron patterns, as the number of castings required may indicate, and mounted on the roll-over molding machine.

An interesting casting for a rather different line of product made by the Harrison Safety Boiler Works is the drum for their Creasey ice breaker. This drum casting is similar in shape to a pulley with a very heavy and wide rim. A hub, supported by spokes, being required in the center of the casting, and a number of lugs and openings being required on the rim for the attachment of the picks which break the ice.

A great deal of difficulty has been experienced in the making of these castings, by reason of the fact that the setting of the main core displaces the cores which form the openings in the rim referred to and which should cut through to the main core.

They are now successfully made by making the pattern hollow, with a removable end, and boring it at the center for a spindle. The spindle is solidly fixed in the mold, the pattern let down over it, with the prints for the cores through the rim and the lugs on the rim screwed on from the inside of the pattern.

After ramming, the removable end of the pattern is taken off and the screws holding the prints to the rim removed. The spindle then forms a guide for drawing the main pattern from the mold, after which the prints are drawn in, the small cores set around the circumference, and the main core set by using the spindle as a guide, the crab on which this core is rammed being bored to fit the spindle.

The box for the main core is parted in the plane of the spokes, and the spokes and hubs made loose in the box, so that they can be drawn from the core.

Manufacture of Car Wheels.

To many observers, car wheels are apparently all alike. There is, however, an infinite variety of styles, as well as sizes, and a

very large and extensive pattern equipment is required to turn out the various kinds of wheels called for.

The Lobdell Car Wheel Company, of Wilmington, Del., has a most complete pattern equipment for turning out all varieties of wheels, and the arrangement of these patterns, both as regards changes in the patterns to meet various specifications and as regards storage of the many parts required, is an object lesson for any foundryman.

The wheels are listed primarily according to diameter. They are very roughly subdivided as wheels of the type furnished to steam roads, wheels of the type furnished to electric roads and double-flanged wheels, such as are used by crane builders.

The wheels for steam roads are further classified as single plate, double plate, Washburn (part single and part double plate), open plate, wave plate and spoked wheels. These are again classified as having the bearing inside the wheel or outside the wheel, and further according to the weight of the casting.

Under these, in turn, is an almost infinite variety of lengths of hubs, over all, and projection of hub to one side or the other, as well as widths of tread, thickness of flange and contour of tread and flange.

Each different contour of tread and flange requires its own equipment of chills, the various chills being designated by number.

The Lobdell pattern list contains full information, with reference to all of the above points, as well as number and material, of patterns on hand and limits of adjustment on the pattern, together with other information which would not be of general interest and will not be referred to here.

It is the universal practice of the Lobdell Company, in the construction of its patterns, core boxes and flasks, to avoid the use of dowel pins as a means of location, all parts being located by turned or planed shoulders. Where dowel pins are used at all they serve only to prevent rotation on circular fits.

This is a practice which might well be adopted by foundrymen in general, as the matching of patterns, core boxes and flasks so obtained is far more accurate than can be obtained by means of dowel pins, and owing to the very much larger bearing surface so obtained will remain so for a longer period.

The wheel patterns are made of pine, pine mahogany faced,

mahogany, mahogany iron faced, or wholly of iron, according to the number of castings required.

The hubs, flanges and treads are made as small as the smallest casting required, and turned with locating shoulders into which fit the various loose pieces, making different widths and thicknesses of tread and flange, and different diameters and lengths of hubs.

The hub core boxes are made of one length and the core prints which are attached to the hubs are made of one length, over all, regardless of the length of the hub, the extra length of print in the case of shorter hubs being put to the drag side, so that all cores for hub holes are interchangeable.

The depth of the flange, from the parting line on the flange to the position of the gauge point on the rail head, cannot be varied except by changing the chill, as this portion of the wheel is cast against the chill. It is possible, however, to use different chills with the same pattern and thus vary this dimension.

The depth of the flange, from the parting line to the back or side away from the rail, can be varied by using different flanges on the same pattern, this portion of the mold being made in sand.

Other dimensions which may vary are distances from the parting line of the flange to the ends of the hub, this being accomplished by changing the hubs on the pattern.

The process of molding car wheels at this plant consists of bolting the chill to the cope flask, laying the pattern into the chill with the cope down and using the cope as a match against which the drag is rammed, after which the whole is rolled over and the cope rammed in the usual manner.

It might appear to the uninitiated that it would not be necessary to fit the pattern to the chill, as this portion of the pattern does not form any part of the mold. As a matter of fact, however, the pattern must be very accurately fitted to the chills, so that there will be no rock when the pattern is rammed up. Any springing or rocking of the pattern in the ramming process would result in variations of thickness in the rim or flange, and as the castings are used without machining, such variations on this surface would occasion rejection of the wheels.

The chills also have to be very accurately machined, not only to give the casting the proper contour, but because the inspectors

make measurements of the castings to determine the amount of shrinkage, the shrinkage being a check on the physical properties of the metal in the wheel. Inspectors, therefore, demand that the chills be maintained exact to diameter and gauge, so that this measurement can be made.

What has already been said concerning the variety of patterns, and more particularly the great variety of changes which must be provided for in each pattern, will give some idea of the problem of storing the patterns and their numerous parts in such a way that any pattern and its corresponding loose parts, as may be required to fill any particular order, can be found without undue delay.

It is the practice of the Lobdell Company to divide its pattern storage into sections, arranging the sections according to diameter and general style of wheel, and giving each wheel pattern a section which contains all the flanges, treads and hubs applying to this pattern.

Each section is plainly marked at the end nearest the main aisle, showing what it contains, and they have even gone so far as to attach to the end of a section of shelves, where it will be visible from the main aisle, a plan of the shelves with lines denoting various compartments, and in the spaces are laid off the numbers of the patterns contained in the compartment. By this means, it is possible to instantly go to the exact place where any particular pattern is stored, without reference to any card index or other filing system.

The cores which form the space between the double-plate wheels, or the double-plate portion of the Washburn wheel, are made in boxes which serve as core driers as well. The surface of these cores, forming the interior of the casting, need not be highly finished, which makes it possible to construct the boxes in this way.

The box itself forms the lower half of the core and the prints which support it in the mold, the center of the box being bored to take a loose piece, which, in turn, centers a strickle, which is used to form the upper half of the core.

A gauge, fitting onto the box, in exactly the same way as the strickle does, is then applied to locate the anchors which hold the core down in the mold, thus determining the uniformity of the thickness of the plates in the castings.

Another interesting device which deserves more general application was observed in the core room of this plant. It consists of a guide, fitting the top of the core box and bored for the vent wire, so that it guides the vent wire as it is inserted into the core and determines uniformity of location.

Data in Reference to Mounting Patterns for Molding Machines.

The manufacturers of molding machine equipment have been relied on, to some extent, for data in connection with special adaptation of pattern equipment for use on molding machines.

The use of the vibrator to assist in drawing the pattern is quite general. The vibrator does not appreciably enlarge the mold, but simply overcomes the friction of the pattern against the sand, and consequently while a pattern without any draught can be drawn perfectly, care should be taken that there is no back draught.

The mounting of patterns for use on power squeezing machines is thus described by the Tabor Manufacturing Company, of Philadelphia:

Vibrator Frame.

To properly suspend a pattern in a vibrator frame, a carrier of sheet brass, 1/8 inch thick, is fastened to the pattern or gate of patterns. The way in which this carrier is fastened must depend upon conditions, soldering or sweating, however, being the most common.

In putting a carrier on a gate of patterns, it is desirable, if possible, to attach the carrier to the runner, as this will eliminate some grinding of the castings, and if the patterns are light, will allow a slight spring of the patterns in the match when ramming the drag, thus assuring that there will be no springing of the pattern when the cope is rammed on the drag.

The next operation is to locate carriers in the slot of the vibrator frame to meet those fastened on the patterns. These carriers should be rigidly fastened, but easily removable. To accomplish this, after the carrier has been inserted in the slot in the vibrator frame, two 3/16-inch holes are drilled through both frame and carrier, and a brass pin is snugly driven into each, but not riveted over.

Holes are now drilled in the carriers on the pattern, and the pattern is put in the vibrator frame, all carriers meeting, and the place to drill the carriers in the frame is marked with a scribe from the holes already drilled in the carriers on the patterns.

This method has been found much quicker than clamping the carriers together and drilling through both at once, and at the same time is sufficiently accurate for the purpose.

FIG. 7.—LAWN MOWER PART MOUNTED FOR TABOR MACHINE. COPE PLATE, COPE MOLD, COPE SIDE OF CASTING.

The slot in the vibrator frame should be filled with wax, to prevent crumbling of the mold at the edges.

Making the Hard Sand Match.

Put the vibrator frame into the cope flask, ram up and make the parting in green sand. Use lycopodium on the parting between the green sand and the match preparation.

Put the match frame, which should be beveled to hold the match in place, over the pattern as parted, and clamp it in place so it cannot move when the match is rammed.

For the match compound, put 15 pounds of new burnt molding sand through a No. 30 sieve, and into this knead one quart of boiled linseed oil, to which has been added 4 ounces of litharge.

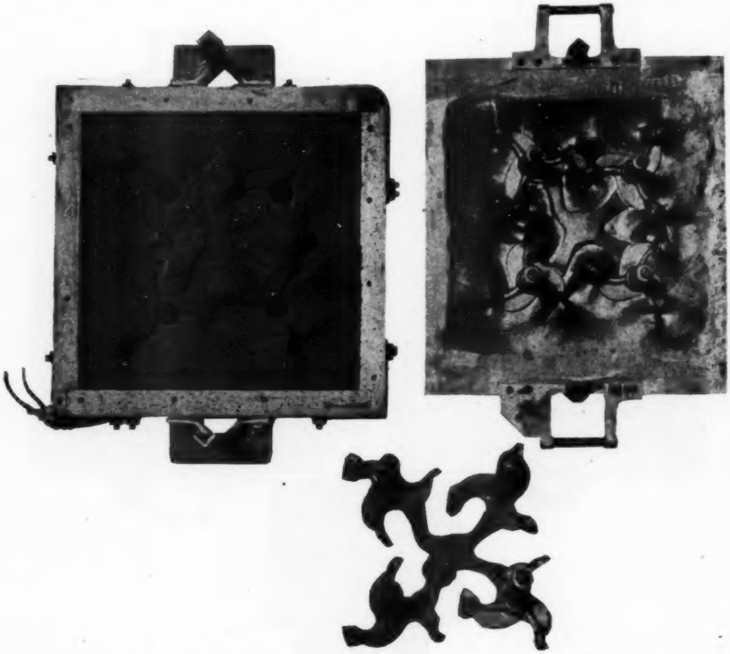


FIG. 8.—LAWN MOWER PART MOUNTED FOR TABOR MACHINE. DRAG PLATE, DRAG MOLD, DRAG SIDE OF CASTING. ILLUSTRATES IRREGULAR PARTING.

Ram up the portion of the pattern extending into the match frame precisely as in hand-molding, strike off and screw the bottom board in place.

Roll over the match, pattern and green sand half and "cope off," then draw pattern and mend such parts of the match as are broken in drawing.

Let the match stand in a warm, dry place for 10 to 12 hours, when it will be ready for a thin coat of shellac.

Aluminum Match Plates.

Where exceptionally good castings are required from patterns having an irregular parting, an aluminum match plate may be used to advantage.

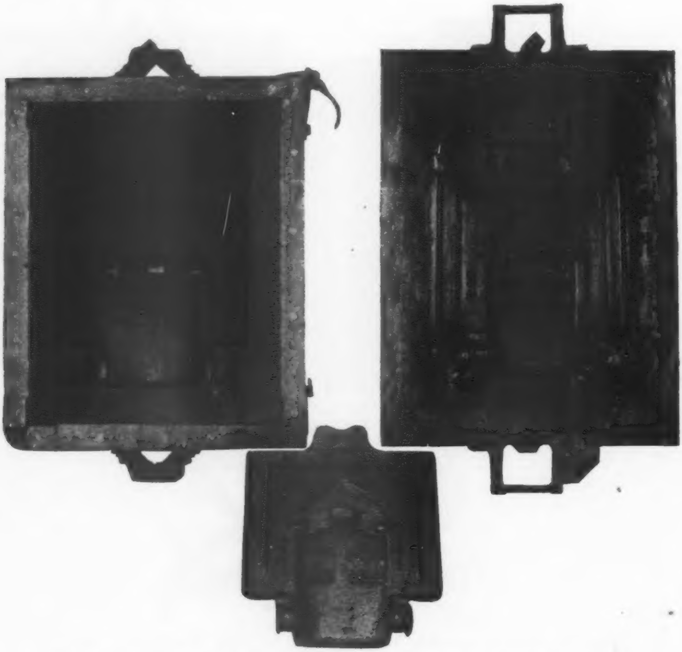


FIG. 9.—JOURNAL BOX COVER MOUNTED FOR TABOR MACHINE. DRAG PLATE, DRAG MOLD, DRAG SIDE OF CASTING.

In using these plates, not only is the possibility of shift overcome, but a whole mold is squeezed at one operation.

In making an aluminum match plate, a master pattern should be used to allow for shrinkage and finish.

To make one of these plates, a mold is made in the usual way in a flask large enough to accommodate the size plate re-

quired. The mold should be made very carefully, in order to obtain a perfect casting, thus avoiding any unnecessary finish in the plate.

When the mold is ready to close, strips of wood the thickness of the plate desired are placed on the parting of the drag, and a false parting of sand built up to the level of the strips.

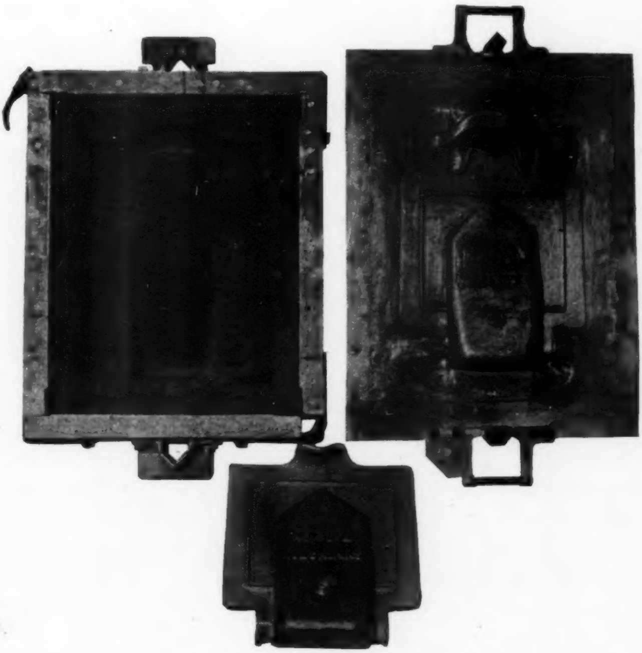


FIG. 10.—JOURNAL BOX COVER MOUNTED FOR TABOR MACHINE. COPE PLATE, COPE MOLD, COPE SIDE OF CASTING.

The strips are then removed and the mold closed and poured in the usual manner.

Care should be taken that the flask pins are in perfect condition, so there will be no shift.

After the plate casting has cooled, it should be rubbed with a fine, stiff wire brush, which is usually sufficient finish, but any fins or irregularities must be removed with a scraper.

When the plate has been thus finished, suitable handles with guides are attached to the ends, and the plate is ready for use.

Paraffined Board.

Paraffined boards are used principally for short runs of work made from wooden patterns that are either "flat backs" or split.

A board, made preferably of oak that has been boiled in paraffine for 48 hours to prevent warp from contact with damp sand, is fitted into a vibrator frame and the patterns mounted on one side, if "flat backs," or on both sides if split patterns are used.

In mounting split patterns on a paraffined board, dowel pins should be used to locate the same, in order to overcome the possibility of a "shift," and then the patterns may be securely fastened in place with wood screws.

In the case of "flat backs," however, the patterns may be secured to the board in any way that may be convenient.

With this method the whole mold is squeezed in one operation, the same as with the aluminum match plate.

Steel Plate With Guides.

The steel-plate method is used for split patterns from which castings are to be made in quantities.

A steel plate 3/16 inch thick is made the size required, and suitable handles with guides are attached to the ends.

The patterns are mounted one-half on each side of the plate, and the whole mold squeezed at one operation, in the same manner as the aluminum match plate and the paraffined board.

In making patterns for use in this way, corresponding halves of patterns should be clamped together and finished to have them match at the parting line, and before they are unclamped a hole should be drilled and slightly countersunk as near each end of the pattern as practicable.

The patterns are now separated, and one-half is laid on the plate in the position desired and the plate is drilled, using the half-pattern as a jig, after which the corresponding half-pattern is placed on the other side of the plate and a piece of brass stock of the proper length inserted in the drilled holes and riveted down to the countersink. These rivets should not be drawn down too tight, in order not to shift the patterns.

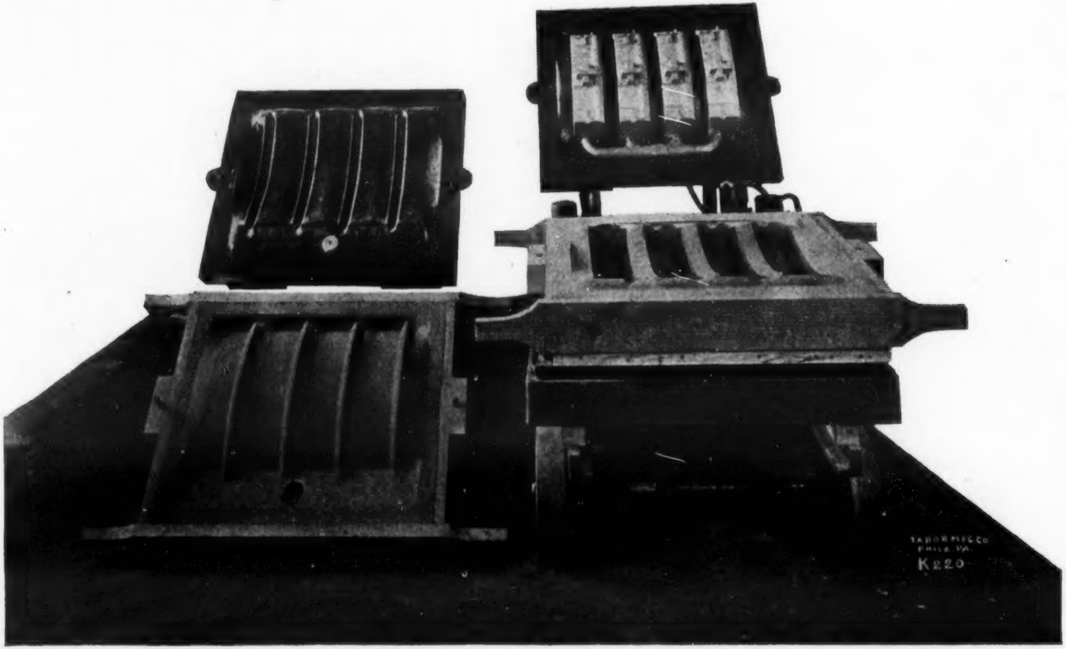


FIG. 11.—BRAKE SHOE ON TABOR ROLLOVER MACHINE.
PATTERNS, DRAG MATCH AND DRAG MOLD ON MACHINE; COPE MATCH AND COPE MOLD AT LEFT.

Sheet steel, 3/16 inch thick, such as is used for tank and boiler work, may be used for these plates, but a more satisfactory equipment is obtained by using saw disc material ground on both sides, thus saving the time consumed in straightening the ordinary sheet steel.

The Tabor Manufacturing Company has also furnished blue print showing mounting of railroad journal bearings.

The usual practice is to mount four 4 x 7-inch M. C. B. journal brasses in a 14 x 16-inch flask, four 5 x 9-inch M. C. B. journal brasses in a 16½ x 21-inch flask, two 6 x 9-inch M. C. B. journal brasses in a 13 x 20-inch flask and two 5½ x 10-inch M. C. B. journal brasses in a 16 x 26-inch flask. These are molded from separate cope and drag plates.

Brake shoes are handled by the same concern on separate cope and drag plates, being made in this case with the assistance of stripping plates, the practice being to mount two M. C. B. standard Christy shoes in a 12 x 16-inch flask, three in a 16 x 16-inch flask.

Cuts of other patterns mounted by this company are shown herewith.

The Tabor Manufacturing Company has recently developed a special table, to be applied to jarring machines, in cases where very few molds are to be made from split patterns. One such device consists of six holes for flask pins, so arranged that these different lengths of flasks can be used without changing the table.

The table has, in addition, center lines at right angles, to facilitate the location of the pattern, and smaller holes, symmetrically drilled and numbered, into which pins are driven close to the pattern, which is prevented from shifting by driving small wedges between itself and the pins referred to.

The symmetrical drilling of the holes makes it readily possible to properly locate the halves of the patterns for cope and drag without laying out or measuring, by simply putting the pins in corresponding holes.

A modification of this device consists in a table with the holes for flask pins, as above referred to, and shallow slots running at right angles intersecting in the center of the table. The patterns are located by screwing metal strips to them, fitting the slots.

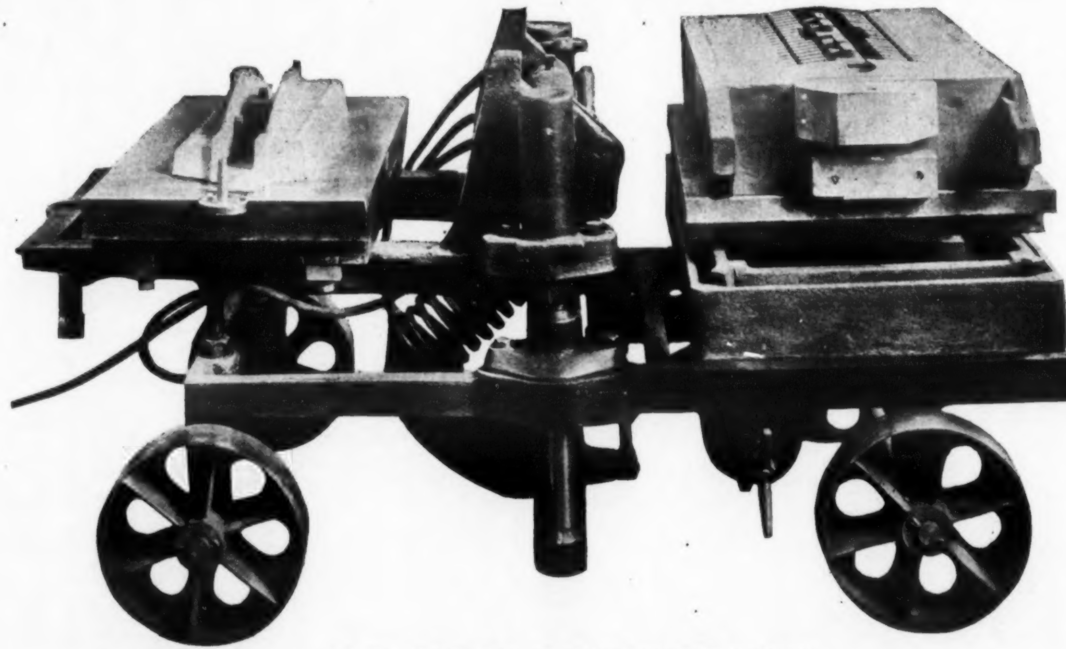


FIG. 12.—GRATE BAR ON TABOR ROLLOVER MACHINE.
DRAG EQUIPMENT ONLY SHOWN.

A rather special case of application of patterns to molding machines is that required in the multiple method of molding on the Rathbone machine, now handled by the Hanna Engineering Works, of Chicago.

Multiple Molding Machines.

In the multiple method of molding it is necessary to mount one portion of the split pattern on the upper head of the machine and the other portion on the lower head, as a complete mold is rammed up in one flask section, and when such flasks are piled one above the other a complete mold is given at each joint of the stack.

The only scheme of mounting these patterns is to get them accurately matched with relation to the center line through the dowel pins on the pattern plates, so that when the pattern plates are attached to the vibrator frame in the ramming heads the patterns will be in alignment.

There is no hard and fast rule for mounting the patterns on the plates, the only requirements being accuracy on the part of the patternmaker in doing the work.

To mount patterns requiring an irregular parting the same general scheme can be followed as in the making of match plates, the only difference being that the plates must be made sufficiently thick, so that they can be split or sawed apart.

An interesting example of work done on this machine is the land side of a plow, the point of which is back draughted and requires a chill.

The pattern is drawn from the mold by mounting it on an inclined axis, so that it will swing out.

The Arcade Manufacturing Company, of Freeport, Ill., publishes a pamphlet, entitled, "Pattern Plate Making," which fully describes the making of pattern plates, and gives the mixtures of the alloy used for metal plates and the composition used for composition matchplates.

The J. D. Smith Foundry Supply Company, of Cleveland, Ohio, handles a composition known as the Bayer pattern composition, which resembles hard rubber in appearance and is used for making pattern plates.

The Goodale Company, of Kalamazoo, Mich., makes matchplates from patterns furnished by its customers.

Pattern Shop Equipment.

The machine equipment of the pattern shop probably does not call for detail mention in the present paper.

Certain of the less usual devices for pattern shop use have been called to the writer's attention and seem to deserve some mention.

Among these is the angle bandsaw, manufactured by the Crescent Machine Company, of Leetonia, Ohio. This machine has the advantage of being so arranged that it can be set to saw at various angles and still retain the table in a horizontal position for convenience in handling pieces on it.

The same concern also furnishes a safety head for jointers. A circular safety cylinder for hand planers and jointers is also furnished by the Oliver Machinery Company, of Grand Rapids, Mich.

The same concern builds, as part of an extensive line of pattern shop machinery, a combination pattern lathe, which has movements which can be adjusted in all directions for accurately turning all shapes of patterns.

Another device which is perhaps little known is "Oliver's Little Pattern Makers," which consist of cutters which can be applied to any machine having a revolving spindle, and which are very convenient for working out patterns and core boxes which would otherwise have to be worked out by hand.

The Wadkin Universal Woodworker, built in England, and handled by the Oliver Company, and also the Oliver Company's own universal wood milling machine, have been quite extensively advertised and discussed.

The universal wood milling machine is provided with adjustments and movements in all directions, and graduated so that patterns and core boxes can be very readily worked out without previous laying out or scaling, the angles and dimensions being taken directly from graduations on the machine.

This is entirely in line with current practice in machine shop tools, and would seem to be an important step in advance in woodworking.

Another extremely useful tool is the disc sander. These machines have been used for a considerable time in metal work, but not so extensively for woodworking. They can now be ob-

tained built specially for woodworking, and with proper angular adjustments for the table, and various gauges and quadrants to be used on the top of the table, thus being particularly adapted for patternmaking. They have the advantage over the ordinary type of trimmer, that compound angles can be obtained, and that the surface produced is equally smooth, regardless of the direction of the grain in the wood. Such machines can also be used for forming convexly curved surfaces.

These machines are offered by several makers, those built by the Oliver Machinery Company and the Gardner Machine Company, of Beloit, Wis., having been particularly called to the writer's attention.

Conclusion.

Enough has, perhaps, been said to indicate the conclusion that, in considering the form which a pattern equipment shall take and the means for its construction, the paramount question is one of economy and efficiency; greatest output per unit of input.

It has been, without doubt, the observation of every member of these associations that the one universal law of high efficiency applying to all industries is the more efficient utilization of human agencies. It may here be said, without fear of contradiction, that every mechanical development that relieves the workman of muscular effort, and leaves him more time and energy for mental effort, contributes alike to the welfare of employer and employe.

In the pattern shop the capable workman can work much faster with his head than with his hands, and his skill and manual dexterity is applied to the best advantage when devoted to the intelligent handling of mechanical equipment, specially, adapted to patternmaking.

In the foundry the expert molder can make his services more valuable and his own work more agreeable to himself when devoting himself to the adaptation of labor-saving machinery to the needs which he alone understands, and to the direction of the efforts of less skilled men than when pounding sand.

This paper would not be complete without an acknowledgment of the hearty co-operation of the manufacturers who were consulted for the necessary data and of the generous invitations

to visit the plants referred to in it, as well as many others which could not be visited because time would not permit.

In concluding the present paper, the writer ventures to express the hope that he has succeeded in some measure at least in gathering and analyzing data furnished by others, and in presenting it in such concrete form as will recommend it to the consideration of abler men than himself.

PROGRESS IN HEATED FOUNDRY MIXERS

By J. B. Nau, New York City.

At the meeting of the American Foundrymen's Association, held in New York in June, 1905, the writer recommended the use of a heated mixer as an intermediary receptacle placed between the blast furnace and the foundry, into which iron from the blast furnace could be poured, kept liquid for any desired length of time, its quality corrected by suitable additions of either liquid or solid pig iron, or by additions of wrought scrap, should it be desired to obtain a metal with lower carbon content. From this mixer the metal was to be withdrawn whenever needed in the foundry. Its use was more especially recommended in pipe foundries.

Since then some progress was made in that direction, but less in this country than in Germany where foundry mixers are stated now as being introduced in different places, and where, up to the present at least, their use is particularly advocated wherever possible as a valuable addition to cast iron pipe foundries.

The writer knows of one pipe plant of modern design, which he had an opportunity to visit in Europe in 1905, and which plant, for lack of capital, was not in operation at the time of the writer's visit. It has since been bought up by a neighboring blast furnace plant, located at a distance of some two miles and will be put in operation as soon as a suitable mixer is put up at the pipe plant, to which the liquid iron from the two blast furnaces will be delivered.

Like all modern mixers used in steel works, foundry mixers are usually in the shape of the Open Hearth. Tilting furnaces, either enclosed in a round iron shell or preferably, in the more modern ones, with the top of the roof exposed to the open air for the purpose of keeping it cool and making it more durable. Their heating is generally done by producer and even in some cases blast furnace gases.

Air regeneration is deemed sufficient for obtaining a good

steady temperature. In some cases, even where sufficient proximity allows heated air from the blast furnace, hot blast stoves are recommended, so as to avoid regenerators.

In this country there is at least one foundry mixer in use in a well-known Western plant where for about two years now 250 tons of mostly very heavy castings are made every day in a ten hour shift, with direct iron from the blast furnaces suitably mixed in a 100-ton mixer before pouring it into molds.

The mixer, without regenerators, is of the tilting style, brick lined, oil heated, and as the castings poured from the mixer irons are very heavy and the temperature of the iron at the moment of pouring into the mixer is high enough for the foundry operations, only a small amount of oil is used for heating purposes.

The Silicon content varies within the extreme limits of 1.25 and 1.75, while the Sulphur is generally kept between .06 and .035. The latitude in the Silicon content makes it possible to do away with any additions of pig or scrap, or other suitable alloys, which additions would otherwise be necessary to correct the quality of the iron.

Direct iron from the blast furnace is brought up in 30 ton ladles and the choice of the iron to be taken to the mixer is left to the care of a man trained especially for this purpose.

The question of the use of a foundry mixer becomes more complicated, where the iron is destined to be used for small castings, and has to be at a necessarily higher temperature, where the Silicon content is allowed to vary only within narrow limits, and where it is desirable to carry the same Silicon content throughout.

Under such conditions outside additions of a suitable kind will have to be made to bring the metal to what might be called a standard analysis. When furthermore the nature of the foundry-work is such as to make it unavoidable to keep the liquid metal in the mixer exposed for hours to the action of the flame, some further precautions will have to be taken to prevent the gradual desilicizing of the foundry iron under the action of the flame as well as the slag that may form during the operation.

In this respect the operations in the foundry mixer will differ entirely from the operations carried out to-day in the

mixer used in connection with Open Hearth furnaces. In this mixer partial refining of the metal is contemplated and fostered. In the foundry mixer on the contrary desilicizing must be avoided.

From the treatment of liquid foundry iron in a furnace, where the writer took precautions against refining of the metal from the first moment on, it was proven that with the formation of a thin layer of slag of a non-refining nature on top of the liquid bath of metal, foundry iron can be kept exposed to the action of a flame at a high temperature for an indefinite length of time without in any way changing the Silicon content of the metal and without deteriorating it in the least. In this respect the writer ventures to state his belief that the metal will rather improve in quality.

Iron running from the blast furnace into a ladle will naturally lose through oxidation some hundredths of one per cent. of its Silicon content. With only ordinary precautions this loss can be well kept within 0.10 of that element or not more than will naturally take place with iron running from the blast furnace into the pig iron molds. During its transfer from the blast furnace, some of the Sulphur and Manganese will be eliminated by mutual reaction, the resulting product finding its way into the slag where together with the silica, and some FeO formed, and some other impurities, it will constitute a thin protective slag covering preventing any further outside oxidation. Pouring the metal from the ladle into the furnace above the slag will form a protective cover over the metal bath in the furnace.

It is not enough, however, to interpose such a layer of slag between the metal and the flame, but it is further necessary to make and maintain the slag of a non-refining nature, otherwise the slag itself would desilicize the metal much more than an oxidizing flame could do it. Such a slag can easily be obtained with the application of some very elementary precautions that can easily be carried out and that have for purpose the formation of a slag low in refining elements.

The non-refining slag that the writer produced in the three first heats made in the treatment of more than 80,000 pounds of foundry iron amounted to less than 500 pounds and had in its composition:

$$
\begin{aligned}
SiO_2 &= 56.720 \\
FeO &= 3.605 = 2.805\ Fe \\
Al_2O_3 &= 13.140 \\
MnO &= 6.700 \\
\hline
&\ 80.165
\end{aligned}
$$

balance undetermined.

Assuming that half of the *Si* of the slag is derived from the iron and the other half from the refractory lining, which was only very slightly attacked, it will be found that only 0.08 of the Silicon was eliminated and this happened mostly in the ladle.

An examination of the analysis of the slag will show that only about 120 pounds of its weight can possibly come from the iron, corresponding to 0.15 in weight of the 80,000 pounds of iron treated as against 4.5 = 3,600 pounds loss that would have happened in the cupola.

The Sulphur and Manganese content of the iron from the mixer are less than the corresponding contents of the iron from the blast furnace. The Silicon may be made any desired amount with suitable additions and once the amount established it can be maintained without variation for any length of time from the beginning to the end of the cast. But if the iron in the furnace is left exposed to the refining action of the flame and the slag, without taking any precautions against refining, slow desilicizing, that in a special case corresponded to about 0.10 elimination of that element per hour, will take place.

With the necessary precautions against desilicizing, it was found that an iron with 1.90 *Si* at the moment of pouring the metal in the furnace, contained 1.86 of that element after nineteen hours of exposure to the hot flame.

By additions of ferro-silicon, the silicon was sought to be increased to 2.30, while it actually reached 2.28, at which figure it was maintained to the end of the cast twenty-eight hours after the iron was poured into the furnace.

The few figures thus submitted show sufficiently what the application of the mixer to the foundry will do for the latter.

The advantages derived from the use of the mixer, therefore, comprise the complete avoidance of the loss of Silicon and furthermore a very notable reduction of the Sulphur content

with a correspondingly slight reduction of Manganese from the iron. With some 0.5 to 0.8 of Manganese in the iron the Sulphur will be reduced by some 10 per cent. to 25 per cent. of its original content even if the iron coming from the blast furnace contains only 0.03 Sulphur or less.

Mechanical tests made with the iron from the mixer also show an increase in strength of about 40 per cent. over what the same iron after its remelting in the cupola would show.

The mixer, therefore, greatly improves the quality of an iron that by its treatment in either the cupola or the air furnace would be deteriorated within varying degrees. Owing to this characteristic the mixer will find its place in other foundries than those of large and heavy castings and of large tonnage. Wherever the quality of the castings to be obtained overshadows their price to a sufficient degree, the mixer can be built in very small units.

In nearly every case where direct metal from the blast furnace is available the mixer can easily take the place of an air furnace.

Air furnace metal costs on an average half a cent a pound more than cupola melted metal. While in some cases mixer metal might cost more than cupola melted metal it would nearly invariably cost less than air furnace metal, and metal for metal it would be of superior quality than the air furnace product. For instance rolls that to-day are cast from air furnace metal could be made more cheaply and of better quality from mixer metal.

WHY COST SYSTEMS FAIL

BY S. E. NOLD, ALLIANCE, O.

To gather up all lines of expenditure applying to production in the operating department, and to transmit the same, in the most intelligent, comprehensive and useful form, to the executive department, that is the work of the cost department.

The man who takes a system, and faithfully and accurately applies it to the data the system brings to his desk, is a good cost clerk.

The man who finds the weak spots in the system (all systems have weak spots) and finds a way of strengthening them, who sees new conditions, and provides for them, who studies to make his reports more useful to those requiring them, that is the cost man.

The man who seeks, through the experience and knowledge of others, adding to that his own experience and deductions, the best methods and plans for gathering data, and assembling and distributing the same so as to show a truthful exhibit of the cost of production in manufacturing, and teaching others how to carry out his plans, that is the work of the cost system man.

That many cost systems of to-day are not satisfactory, is proven by the great demand for information along this line. Close competition has made it imperative for the manufacturer to know, not *about* what, but *just* what his product is costing.

The man who comes with a panacea for all cost troubles by the use of certain forms and directions, is in the same class with the street faker, who, for the price of one bottle, agrees to cure all known, and many unknown, diseases of mankind. For this very good reason, I will not try to give you a cost system, but will endeavor to tell you why some cost systems fail.

There is no reason why we should consider, even for a moment, the incompetent cost man. He is no cost man, could never get within sight of a cost. He will speedily be relegated to the scrap pile of failures.

The cost man is usually looked upon as the trouble man of

the place, and I am sorry to say, we cost men too often have given opportunity to the charge. We have drawn straight lines with sharp angles about our systems, and expected them to fit, instead of fitting our systems to the conditions, but proved a case of square pegs into round holes. We have been surprised, when those on whom we depended, did not rush to us with the information our systems called for. We dominate over them, instead of asking their help to solve the problems—forget we were not bosses but co-workers.

Wonderfully elaborate and scientifically correct systems, dealing with the minutest details, and providing for infinite classifications and exhibits, their only merit being profundity and immensity, and providing employment to a small army of clerks, remind us of the young doctor, describing to the old practitioner a case he had treated, how perfect, scientific, profound and humane it had been. "How about the patient?" the old doctor inquired. "Oh! he died." Systematis superioris would fit the diagnosis of either case. It takes a hog-latin term to describe either.

I have pleaded guilty to the weaknesses of the cost man, but there are others who are heavy contributors to causes of failure.

The human element of opposition to change is fearfully strong in many men, and is difficult to overcome. The man who will not change with changing conditions is a boulder in the road, against which everybody gets a bump.

The human element of indifference is as bad, if not worse. With an obstinate man, you have something to meet and overcome. With the indifferent man you are fighting the air. Indifference is only another term for lack of co-operation, and co-operation, as in all human lines of endeavor, is the keystone of success in cost work, and lack of it foredooms the best system that can be devised.

To a foundry cost man, the foreman must be authority for most of his data, and the cost report should be a treasure-house of useful information to the foreman, an intelligent exposition and comparison of facts about the foundry work. It is only after working with a foreman who had taken pains to answer all your inquiries, and with whom your appeals for help have been manfully met—then falling in with one from whom information

came like pulling teeth—it is only then that you can truly realize what a real co-operative foreman can be to a cost man.

But co-operation with the workmen and foremen still leaves a weak link in the chain of cost work. Co-operation must begin and end with the man higher up. Lack of a common head, allowing each department to be a law unto itself, is a fruitful source of trouble-breeding conditions, and sure to defeat co-operation. As each department contributes to the other departments, each depending on the other, one power must control, direct and unite all, the power that comes from the man higher up.

The express train speed of moving events and change in nearly all lines, has left excellent systems of a decade ago, obsolete and worthless for to-day. New methods in manufacturing call for adjustments in cost systems to fit the new conditions, and the cost man who fails to keep pace with the procession, will speedily find himself down and out.

THE PATTERN SHOP APPRENTICE.

By Jabez Nall, Cleveland, Ohio.

Maintaining the supply of good, capable, all-around mechanics, in any and all lines of handicraft, should be a matter of concern and deep interest to all who are in control of the management of manufacturing establishments. Particularly is this true of the pattern shop and the foundry, which to-day demand a greater skill and a more diversified knowledge in the production of castings, the variety in design of which cover a wider range than ever before. For instance, as to transportation power alone, we can step from the flying machine, with its concentrated energy and high power bound within the limits of a few pounds of metal, onto the deck of an "Olympic," with its 50-ton cylinders and other massive pieces of machinery. Also, in recent years, the perfection of the molding machine has demanded new ideas in patternmaking, or at least a varied application of old-time principles in the arts of patternmaking and molding to meet new conditions. In some trades the machine may have, to some extent, displaced the man or converted him into an automaton, but this is not true of the patternmaker. While the past few years have witnessed some improvement in pattern shop machinery, and the introduction of some new labor-saving tools and devices, these merely aid, but in no sense make the patternmaker's work automatic. His efficiency still depends upon his skill as an artisan and his ability to *think*. I am willing to admit that there are advantages in specializing along certain lines of pattern work to obtain the best results, and the patternmaker's special field of endeavor will be developed in large measure by inclination, or by force of circumstance in obtaining employment. The law of the survival of the fittest, and the judgment of the foreman, also have a great bearing on the special line of work the patternmaker will follow. To illustrate this, let me tell an anecdote of an occurrence in a shop some years ago. The "Boss" said to "Ike," who was about finishing his job, "Well, 'Ike,' I guess I'll have to lay you off to-night," and left "Ike" to think it over. Now,

"Ike" was an old hand, and was considered one of the steady pins of the shop. Moreover, he was a good, hard-working Swede, with an eye always on the steady "yob." "Ike," began to wonder what his wife and children were going to do. He worried considerably, and when he could stand it no longer he asked the "Boss" why he was laid off. "Well, you see 'Ike,' I haven't any more fly-wheels." As "Ike's" job was finished by this time, he let him in on the job by giving him another job on a very different class of work, which relieved "Ike's" mind so much that, being a competent man, he went at it with vigor and performed it with credit.

Notwithstanding this specialization of work, which we always find to some extent in large shops, it should be our aim, in the education of the pattern shop apprentice, to produce a mechanic capable of doing any kind of pattern work. He should be able to adjust himself to the job in hand, and not to waste valuable time and energy producing a piano finish on something not worth while. Nor should he have an exaggerated idea of the importance of the microscopic dimensions required on a few patterns, which, if he attempts to attain on the vast bulk of the work, is wasted effort. However, he should be able to do this when necessary and to split the hair-line when required. While it is to the interest of the manufacturer that the supply of such mechanics shall be large and the quality as high as possible, the question arises whether he always takes the best means to attain this end. Does he seek to fulfill his duty to the apprentice, and, if so, by what means? This, however, is but the obverse side of the argument. There is a reverse side. It is to the interest of the mechanic that the supply of those following his vocation be limited, thereby increasing the demand for his services and insuring a higher remuneration for his services. Is his policy of restriction wise? If so, what are the limitations to be placed on such restriction? Where shall we seek the material for the making of the best mechanics? What system, if any, is best adapted for the fullest development of the material at hand? All of these are questions worthy of consideration and which we will take up, briefly, in the order named.

Does the manufacturer take the best means to increase the efficiency and supply of good mechanics? It is an admitted fact

that he feels the need of a better working force, and deplores the kind of help he is able to obtain. He complains of their inefficiency, as he would have a right to do, were it not for the fact that this condition is the result of an antiquated system of apprenticeship for which he is largely responsible. What opportunity is afforded the boy to learn his trade when placed in the shop without any preliminary knowledge of the requirements of the work he is given to perform? He thus becomes a part of cheap help of the shop. If he is kept at this kind of work too long, he becomes discouraged, loses all ambition and early forms the habit of starting the day wishing for its close, and doing as little in the meantime as possible. I do not say this was the manufacturer's idea of getting cheap help when his superintendent or foreman hired the boy. His mind taken up with weightier problems, he has given this little attention or thought, regarding it as the duty of the foreman, perhaps, to attend to the education of the apprentices, and thus dismissed it from his mind.

Under existing conditions, the foreman is too busily engaged attending to the work going through the shop, and looking after the men, to devote any time to the special instruction of the apprentices, beyond such general information as he may be able to give the boys with reference to the job in hand when giving out the work, and a general supervision of the work as it progresses. To teach a boy how to run a lathe, a planer or any other machine tool does not make him a machinist, nor does teaching a boy how to grind, sharpen and handle his tools, so that he can successfully make a glued joint, turn a piece accurately in the lathe or carve a block of wood to given lines, make him a patternmaker. There is other information that he must acquire. In addition to such knowledge of mechanical drawing as he may be able to acquire in the course of his shop practice, he should be taught the principles of projection, such plane geometry at least as will enable him to construct his work with a saving of labor and material. He should also have some knowledge of mathematics, and the more of this the better. It is also essential that he have a knowledge of foundry methods and molding practice. This of itself covers a wide range to-day. He should have other general information pertaining to the trade, such as a partial knowledge, at least, of modern machine shop

practice, of the nature and properties of materials that are used, not only in the pattern, but in the finished casting. He should be taught his duties not only as a workman, but as a citizen. This would tend toward the making of the finished mechanic, the betterment of conditions in the shop and an increase in the output. "What is everybody's business is nobody's business" is an old saying, and it is nobody's business in the shop with the old-time system of apprenticeship to teach any of the foregoing to the boy. Notwithstanding the thorough system outlined, it is frequently impossible to hold some of the boys. They will endeavor to acquire, elsewhere, what they should rightfully receive from the manufacturer, who, by contract or otherwise, for a consideration mutually agreed upon, has promised to teach the boy the trade of patternmaking. To acquire this knowledge the boy devotes four years of his life, at a period best adapted for the purpose, which, once gone, can never be recalled. Not to make an effort, at least, to carry out this obligation, is to rob the boy, not of his wages due on pay day, but of his chance to advance and to lessen his earning capacity all through life. Some boys will advance in spite of conditions. Others, in order to properly advance, must have both a pull from in front and a boost from behind, and may even then fall back. He has a right to his chance, however, being willing, according to his ability, to carry out his share of the contract. To expect the small manufacturer to maintain an apprentice school, with a special instructor, is not justifiable, but he can contribute, with others, to the maintenance of such a school in his locality. I believe in the municipal control of these trade schools in preference to state control, and those who benefit most should defray the cost. One thing, at least, the manufacturer can do, even under present conditions, to improve the quality of mechanics, and that is to make the pay high enough to attract the bright, brainy boy to the trade. There is little that can be said regarding efforts by the workman to restrict the number of apprentices in the pattern shop. In my opinion, such an attempt would be foolish because futile. In my experience I have found very little of it, nor have I found many who would refuse to help out or give the required information to the boy if he but cared to ask. There may be a few "grouches" who would refuse, but I have not met them, and to

do so would be foolish, for the boy may be a "comer" when the "grouch" is a "has-been." The custom of having only four apprentices to a shop cannot be said to be an effort at restriction, as this is about as great a number as the foreman can instruct under present conditions. It has always been the aim of patternmakers' associations, so far as I can learn, to help the apprentice become as capable a mechanic as possible, and to this end they insist on a rigid adherence to and fulfillment of any contract or indentures that may be binding on the boy. With a view of improving the grade of mechanics, the Cleveland association of patternmakers carried on an apprentice school for some time, presided over by a capable and practiced instructor. This was begun as an experiment, and was maintained as long as the attendance warranted its continuance. The school was in session one night a week, but as the boys were compelled to pay a nominal fee for dues, the attendance declined until the school had to be abandoned.

Where shall we seek the material for the making of the best mechanics, or, in other words, where shall we look for the boy, who, by training, will make the best patternmaker? As a matter of fact, it is not necessary to seek, as any establishment employing patternmakers has a waiting list of applicants for apprenticeship. The requirements of the trade are such that they demand, in the successful patternmaker, a high degree of intelligence and power of mental application. This being the case, one naturally seeks the boy whose training and record at school would indicate the possession of this knowledge. Suppose we look over the list in waiting and pick out the boy who is a high-school graduate, or at least had two or three years of high-school training. My experience, and that of others with whom I have talked on this subject, show him to be a failure. Why? I am not willing to decry the advantages of education, because I have felt the need of it in my life more than I care to admit, but my experience with this class of boys shows that they have already been spoiled in the making. Consciously or unconsciously, the professors appear to have imbued him with the idea that he is not only different, but better, than the ordinary run of boys that have not had these advantages and that he should not be asked to perform any menial duty. A friend of mine, who had been

educating patternmakers for the last nineteen or twenty years, and whose graduates have been remarkably successful, many holding important positions, records as his only failure a high-school graduate, who suffered so much from an exaggerated ego that he objected to perform some tasks that the foreman was not above doing himself. Education is a good thing, but the teachers should see that it is practical and coated with common sense. The boys should not be given the idea that they are the only ones who are fitted for leadership and responsibility, and that they must be among the favored few. These boys are not taught how to think for themselves or to apply their knowledge in a practical manner. By way of illustration, I will relate an incident involving one of these graduates who, as his first effort to bring the world to his feet, obtained a position in a machine shop. One of his first duties was to run errands. The store-keeper, being temporarily out of a certain kind of sandpaper required in the pattern shop, sent the boy to the hardware store for two quires. When he asked if he would be able to carry it, the storekeeper, sizing up the situation, suggested that he get a wheelbarrow. Accordingly, he wheeled a heavy, iron shop wheelbarrow to the hardware store and asked for two quires of sandpaper, and trundled his wheelbarrow back to the shop with a package he could have carried in one hand. If he had stopped to think, or endeavored to apply his knowledge, he could have saved himself the mortification of being fooled so easily.

I see no reason why the boy equipped with a higher education should not have a great advantage over the boy who lacks this training, providing this training is practical. If, then, we reject the high-school boy who has mastered the classical course, how about the graduate of the technical school? Will he make any better showing? His training has been along special lines and should especially fit him for the work. This, we say, must depend upon the boy. If he only comes into the shop to take a post-graduate course, and is filled with the idea that all he needs is a few months' shop experience to fit him for an executive position, I don't want him. It would depend largely upon the nature of the course of study laid down by the school, and the amount of time given to the actual work, and whether the teacher was a practical man, with adequate shop experience himself, and who

would naturally keep the shop or commercial idea in view all the time, as to how much it would be necessary for the boy to unlearn, a task that might be more difficult than starting at the beginning. If we are to teach trades in school, let it be in the trades school proper, and let the teaching and development be such that a four years' course will place the students at least on an equality with the boy who has had four years of gruelling practice in the shop. For my own part, I prefer as an apprentice a healthy boy of good habits and a fair amount of animal spirit, who, having graduated from the grammar grades, and has had a year or two of shop discipline and experience, has reached the age of about seventeen and has fully made up his mind that he wants to be a patternmaker, and the height of whose ambition is to be a good mechanic. With this kind of material to work with, I believe, the best of results can be attained. This brings up the last question regarding the system best adapted for the highest development of the material at hand. There are many small pattern shops throughout the country where any special system of instruction or method of procedure in educating the apprentice in the shop is almost an impossibility, because only one or perhaps two are employed. Yet, if a boy is determined to learn, and if the foreman is willing to do his part in carrying out the firm's share of the contract, this apprentice may even have the advantage over the boy who serves his time in a larger shop where some sort of system may be in vogue.

Some of our brightest mechanics are graduates of small shops. It is entirely up to the boy in such a case. If his mind is filled with the thoughts of the pleasure of the previous night, he is not liable to make good. However, if his attention to his work and his disposition is such as to gain the good will and interest of his foreman, his opportunity for individual instruction in a small shop is better than in a large one. Such a boy will usually take advantage of what outside help he can obtain from such educational courses as are offered by such organizations as the Young Men's Christian Association and others. These might be considered substitutes for the special municipal trades school that should exist in every community large enough to maintain them. He should also read technical papers and magazines containing articles relating to his trade. These will prove of great

value to him, as through them he will obtain a knowledge of the ideas of other men than those with whom he associates daily, and he has an opportunity of studying problems that do not come before him in his daily work.

The best that was possible under the old system of apprenticeship, and which, notwithstanding the steady progress in recent years of the advanced or new apprenticeship idea, is still the one under which the majority of the present-day pattern shop apprentices must learn their trade, was the adoption of some method of training in the shop itself, independent of outside services. The plan adopted and practiced by Mr. Walt, of the Cleveland Punch and Shear Works Company, who also handles a large amount of outside pattern work, shows the best results in producing the finished mechanic of any that has come under my personal observation. Whether the success thus attained is due to the system or the man, the results are most creditable. I do not know of any of his graduates that have not made good as patternmakers, and many of them hold positions of responsibility to-day. His apprentice system requires a probationary period of three months, during which time the boy helps wherever possible in lending a hand at sandpapering, varnishing, etc., while he familiarizes himself with his surroundings, the nature of the work and the discipline of the shop. He is given ample opportunity to show what is in him, and to make up his mind whether he wants to be a patternmaker or not. On the other hand, the manager of the shop has time to decide whether the boy is fitted for the work. At the end of this period the parent or guardian of the boy is called in and a contract is entered into, covering a period of four years, during which time the boy is to be taught the trade. The contract stipulates the boy's duties, payments at stated periods and the amount of increase in wages. The shop practice, briefly stated, is to start the apprentice at circular work, simple lathe work, blank gear work, etc. He is given a bench, and is expected to provide himself with the necessary tools. This class of work familiarizes him with the use of machinery and different shop tools, which he has been carefully instructed to handle and has been warned of the peculiar dangers of each tool that might lead to accidents. Having become proficient in this class of work, he is given simple patterns to

make, requiring bench work, and is advanced to better and more intricate work as he shows himself capable to perform it. It has been found that advancing the apprentice as rapidly as is consistent with the thoroughness of his work, makes him ambitious to learn, and is, in the end, more profitable than keeping him on a class of work that he has learned to perform quickly. This is justice to the boy and fulfills the duty of the firm. Throughout this period of instruction the foundry methods are given due weight, and it is to this feature that I attribute the success of this system. In my own personal experience as an instructor of pattern shop apprentices, I have found it most difficult to get the apprentice to take a sufficient interest in the foundry end of his trade. This knowledge is essential to success, as the pattern he makes is but a means to an end and not the end itself. The reason, it seems to me, is due to the boy's wrong conception of the trade in the beginning. In some way he has learned that patternmaking is the best of the woodworking trades, and as he wants to be a woodworker, he does not care to hear much about sand. Sand is dirt, and his preconceived idea of patternmaking was that it was a clean job. When he has to help change some old pattern that has done for years, he gets a chance to revise his notions, and he finds sand is an important feature of patternmaking.

It is much easier to train a woodworker, capable of completing a model, true to size and shape, without a false cut or scratch to mar its perfection, than to train a patternmaker, who, to be proficient, must have some knowledge of machine shop practice and a much more extended knowledge of foundry practice. The up-to-date system of instructing apprentices by means of the apprentice school in connection with the shop is possible only in some of the largest works of the country. This method appeals to me as the ideal. This system, so far as I have been able to learn, has only been applied to the machine shop, and the pattern shop apprentice has been entirely overlooked. I was much impressed with the account of "A German Apprentice School," pp. 832-835, Vol. XXXIII, of the *American Machinist*. The school was conducted by Ludwig, Loewe & Co., of Berlin, Germany. The article was written by Otto Stolzenberg, who devotes his whole time to the work as special instructor. The subjects taught

are numerous, but their application practical. The thing affecting the pattern shop apprentice that impressed me most was the fact that "the pattern shop apprentice is required to give six months, or one-sixth of his time as apprentice to foundry work." Wherever this is possible, as in a shop that has its own foundry, in my opinion, it would be wise to follow this practice here, and to have this feature included in the apprenticeship contract. A six months' course in the foundry I would place as a preliminary to the course in the pattern shop, believing it to be of great advantage. Another feature pointed out in this article was the use made of the magic lantern in the classroom. The possibilities of this as a means of instruction in connection with shop work seems to me limitless, as photographs taken in different shops, showing different methods of doing the same work or different kinds of work, reduced to lantern slides, present the idea to the student in a form he cannot fail to appreciate and understand.

The technical or trade school, apart from regular shop practice, does not appeal to me as capable of producing a mechanic able to compete with the graduate apprentice of a regular manufacturing establishment, and particularly so of the pattern shop. The former is taught under conditions differing too much from the actual conditions he must meet with later. He is brought up as a student among students, with a student's leisure, and if there is competition it is only against others like himself, but the pattern shop apprentice early realizes that he must compete not only with other apprentices, but with the journeyman patternmaker that may work at the next bench, and if he is ambitious his aim will be not only to equal, but to excel, the best man in the shop, and to the apprentice I would say retain this ambition. In the words of Chesterfield, "Know more than others, if you can, but do not tell them so." In a Yankee phrase, "Keep your head level," and in the words of the great Paul, who wrote to his son, Timothy, "Study to show thyself approved unto God, a workman that needeth not to be ashamed."

APPLICATION OF LIFTING MAGNETS TO FOUNDRY SERVICE.

By H. F. Stratton, Cleveland, Ohio.

In general, a device becomes an economic necessity to an industry when its installation will yield a reasonably large return on the investment and when the device has demonstrated, through several years of actual service, that it can be considered reliable and beyond the experimental stage. The word "necessity" is chosen advisedly, because with the existence of such a device some manager more sagacious than the average will make the installation, after which the insistent demands of competition will then compel the general adoption of this economic necessity.

An analysis of such figures as the writer has been able to secure, relating to the tonnage and the cost of handling of the pig used by the foundries in this country, seems to indicate that the lifting magnet is becoming an economic necessity to foundries producing a large proportion of the total foundry tonnage.

There appear to be three huge businesses which can profitably use lifting magnets for the transporting of iron and steel products: First, the steel industry, with probably 10,000,000 tons annually, which can be economically handled by the magnet, and in this industry the magnet found rapid and extensive use, with savings to the steel mills of probably close to one million dollars annually; second, the railroads have discovered that magnets are large money savers in the handling of their scrap material, and probably one hundred lifting magnets are at present in use at the scrap docks operated by the various railroads throughout this country. In several cases the economies effected by the use of magnets in handling railroad scrap have proven to be so large and so obvious as to warrant the installation of very complete equipments, consisting of special cranes, several magnets, and a convenient and scientifically arranged collection of bins, shears, etc. Reference will be made later to the savings effected by railroads in the handling of their scrap material, since this will have a direct bearing on the cost of scrap handling in foundries. For

the present, a quotation from a paper by F. D. Reed, assistant to vice-president of the Chicago, Rock Island and Pacific, will give a summation of this matter.

"Sorting of scrap, the way we handle it here, can be done for from 4 to 7 cents per ton; in other words, we can handle scrap in and out with our facilities for from 10 to 12 cents per ton, including the sorting. Prior to May, 1909 (at which time our crane and magnet were installed), when all scrap was handled by hand, the cost per ton in and out ranged from 30 to 35 cents per ton, which is about what it is costing any railroad to-day that is handling scrap by hand, or even with very good modern facilities for handling, and to keep it down to this figure they must have good and convenient scrap-dock arrangements and efficient organization."

The third industry, which would appear to have opportunities to effect savings by the use of magnets, is the foundry. It has been estimated that the foundries of this country melt annually about six million tons of pig iron and scrap, and although the writer has no definite knowledge of the relative proportions, it would seem reasonable to conclude that of this total about one to two million tons is represented by scrap iron and steel.

Of these three-named industries in which the lifting magnet can apparently be used to economic advantage, the foundry has been by far the most reluctant to embrace or even to investigate the economies which are apparently open to it. The writer trusts it will not be considered presumptuous if he makes the statement that a number of foundries are to-day not using magnets merely because of an apparent antipathy to departing from established customs and methods.

It is the writer's hope to indicate in this paper—fairly and conservatively—the economic possibilities of magnets in foundries, and to outline the costs of installation and of operation of a suitable lifting magnet equipment. This is done with the desire of placing before the foundry manager such figures that he will be enabled to determine what would be his cost of handling by means of a magnet, and assuming that he knows his present cost of handling by hand labor—to enable him to determine by his own investigation if the installation of a magnet equipment would be profitable in his individual case.

An analysis of the costs can be best undertaken from the separate considerations of cost of installation and cost of operation. Later some statements will be made with reference to the severity of service which lifting magnets inevitably encounter, and for the present it is safe to assume that no man, in justice to his company, has the right to purchase any except a well-built magnet. A magnet thoroughly capable of withstanding hard abuse costs about $1300 per ton of lifting capacity of pig iron. Standard magnets are constructed in about four different sizes, and although this figure just named does not hold ac-

FIG. 1.—MAGNET OPERATED ON A MONORAIL SYSTEM.

curately for all sizes, yet it is a fairly close index to the selling price and is sufficiently accurate for purposes of estimate. It may be mentioned at this point that the approximate lifting capacities of these different sizes of magnets in service are, expressed in pounds of pig iron per lift, as follows: 800, 1350, 1950, 2400. Of course, some kind of a crane is necessary for handling a magnet, and if the foundry already has its yard equipped with either an overhead traveling crane or a locomotive crane, the installation of the lifting magnet becomes a simple and relatively inexpensive matter. If it be applied to an electric overhead traveling crane, it is merely necessary to run leads from the crane to

the magnet, and to provide some simple mechanism for taking up the slack in these leads as the magnet is hoisted. If the magnet be applied to a locomotive crane, current can be furnished to the magnet either by suitable plug stations installed at various points in the yard, or an engine generator set can be put on the crane, the generator delivering current to the magnet and the engine taking steam from the boiler of the locomotive crane. This latter arrangement, while more expensive in first cost, is preferable in that it provides a flexible unit which is operative at any place which the locomotive crane can reach. A high-grade

FIG. 2.—MAGNET BREAKING LARGE CASTINGS AT BALDWIN LOCOMOTIVE WORKS.

four-wheel ten-ton locomotive crane, complete with an engine generator outfit, can be installed at an expense of about $5500, and such a crane will handle a magnet at a boom radius of about 40 feet, thereby covering a large area, even if the crane runs on only one track. Of course, by the use of parallel spurs, a large area can be conveniently, cheaply and completely served by the locomotive crane. A locomotive crane is of such general use to a foundry that it is only fair to charge but a portion of its cost to the magnet. The locomotive crane can, for instance, be used for loading and unloading heavy castings and machinery,

and for shunting freight cars. For about $1000 extra it can be equipped with a two-line outfit and a bucket for unloading sand and coal. If we consider that $3000 be a proper proportion of the locomotive crane cost to charge against the magnet, and if a magnet be selected of such size that it will have a lifting capacity of about 1350 pounds of pig iron, the cost of the magnet installation then becomes about $3900, or, in round figures, $4000, installed and ready to operate.

The operating cost of a magnet consists of certain charges, including operator's wages, fuel and oil, which will exist only

FIG. 3.—MAGNET ON LOCOMOTIVE CRANE HANDLING SCRAP.

when the magnet is in operation, and depreciation charges on the equipment which will not depart much annually from a fixed amount, whether the tonnage be sufficient to keep the equipment busy practically all the time or only an hour or two a day. It follows, then, that the operating cost, which is the sum of these two charges, will necessarily be lower per ton of material handled if the equipment can be kept in service the majority of the time. Most foundries, however, do not melt sufficient metal daily to require the services of the magnet more than two or three hours per day. A concrete case will be selected for the double

purpose of indicating how similar estimates may be made to cover any particular foundry, and for pointing out a daily tonnage at which the installation of the magnet and crane appears to be an economic necessity. The assumption will be made that a foundry melts 35 tons of metal daily, 300 days in the year. All of this metal must, of course, be handled twice; that is, it must be unloaded from the car to piles and loaded from the piles to some

FIG. 4.—MAGNET LIFTING A CAST IRON PIPE WEIGHING 4,310 POUNDS.

kind of a wagon on which it is carried to the cupola platform. For a foundry of this capacity the following figures pertain:

CHARGES PER HOUR.

Operator's wages	$0.30
Fuel (at $3 per ton and using ½ ton per 10 hours)	.15
Oil, etc.	.03
Total	$0.48

A crane and a magnet of the size referred to before will conservatively handle 35 tons per hour, which will make a cost of 1.4 cents per ton. The annual depreciation on the $4000 equipment

at 12 per cent. would be $480, and as 35 tons handled twice per day for 300 days represents 21,000 tons handled annually, the depreciation cost on this tonning basis is 2.3 cents per ton. This brings the total cost of handling, including wages, fuel, oil and depreciation, up to 3.7 cents per ton. The writer is told by a

FIG. 5.—TYPICAL LIFT OF PIG IRON.

gentleman well versed in foundry practice that 10 cents per ton is a fair figure to assume for the cost of loading or unloading pig by hand, and on this basis the saving would be $1323 annually, or 33 per cent. on an investment of $4000.

If the case of a larger foundry be selected, melting, say 100 tons per day for 300 days per year, and assuming in this case

that metal is handled more cheaply at, say, 9 cents per ton, by hand labor, the annual saving effected by the use of the magnet is $4080, or over 100 per cent. on the investment. It may be mentioned in the case of the smaller foundry that the time the magnet is in use daily would be about two hours, and in the case of the larger foundry, with the magnet selected, about six hours daily would be required. In this latter instance it would doubtless be more economical to install a magnet having a lifting capacity of about 1950 pounds, instead of 1350 pounds, which was the basis on which the estimates were made.

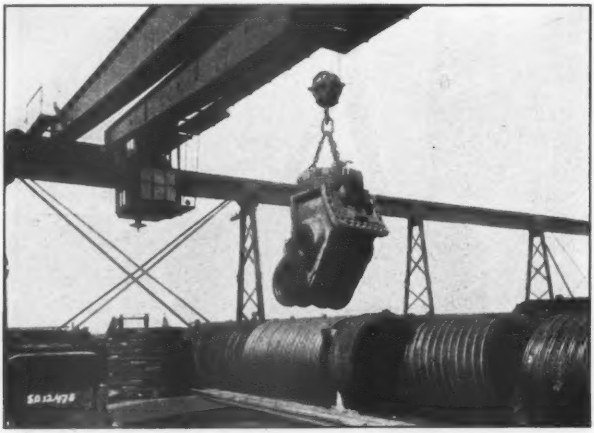


FIG. 6.—MAGNET LIFTING LOCOMOTIVE SADDLE CASTING WEIGHING 4,100 POUNDS.

With these figures fresh in mind, your attention is respectfully directed to this conclusion: A foundry melting 35 tons of metal daily can install both a crane and a magnet, and expect a return upon the investment, after allowing all charges, of more than 30 per cent. If it happens that a foundry is already equipped with either an electric or a locomotive crane, a magnet can then be installed on a very profitable basis when the tonnage to be handled is considerably less. For instance, if an assumption be made that a foundry melts 20 tons daily, and that a magnet be installed on an existing crane, the cost of the magnet being

about $900, then the cost of handling, per ton, including wages, fuel, oil and depreciation on the magnet, is about 2.3 cents, which would represent a saving in this foundry of about $924 each year, or more than 100 per cent. on the investment.

It is very earnestly hoped that these figures be not brushed aside with the assumption that they are theoretical and must be largely discounted. As a matter of fact, the costs of handling by a magnet are stated conservatively, and are being bettered in service daily. The figure of 10 cents per ton for handling pig by hand is an assumption on the writer's part, but from information gained during six years' experience in the manufacture and sale of lifting magnets, it is believed that this figure is not at all at variance with the facts.

Handling scrap, in general, will be more expensive than handling pig iron, whether it be done by hand or by magnet, but the advantage in favor of the magnet is more marked in the case of scrap than in the case of pig. As before stated, the railroads have carefully investigated the comparative cost of handling scrap and large castings by means of magnets and by hand labor, and the following information is therefore submitted as being pertinent to the question of scrap handling in foundry yards. Mr. N. A. Mears, of the Lake Shore and Michigan Southern Railway, gives the following comparative figures:

COST PER TON.

Loading locomotive tires by hand..............	$0.17
" " " " crane with chains..	.08
" " " " " " magnet.	.04
" heavy castings by hand, almost impossible.	
" " " " crane with chains....	.20
" " " " " " magnet ..	.03

Another gentleman identified with the railroads states that it costs, for an average of 100 cars, $7 per car to unload scrap by hand, and $2.83 per car to unload the same character of scrap by crane and a magnet. Mr. Reed, of the Chicago, Rock Island and Pacific, says he can unload unsorted scrap with a magnet at from 2 to 5 cents per ton, and sorted scrap at from ½ to 1½

cents per ton. When this work was done by hand labor the expense was about three times as much.

Exclusive of the economies already cited, certain other incidental advantages attend the use of a magnet, and, in the summation, these would probably be quite great, and any one of them might be very important in some instance. These incidental advantages, somewhat in the order of their importance, may be mentioned as follows:

First. The elimination of labor trouble, this being particularly true where common laborers are apt to be very unreliable,

FIG. 7.—AN ENORMOUS PILE OF PIG IRON STACKED BY A MAGNET.

as in the South, or where the demand for labor for harvesting the crops is extraordinary at certain times of the year, as in the West.

Second. The ability of a lifting magnet to handle a drop ball for the breaking of castings too large to charge into the cupola. For this application the magnet not only serves to lift and release accurately the ball, but also to pick up and transport the broken pieces of the casting. For this particular work, not only is the matter of economy to be considered, but also the question of increased safety to the operator.

Third. The ability of a magnet to unload castings too heavy

to handle by hand, and often of such shape as to be very inconveniently handled even by a magnet with chains.

Fourth. The ability to stock pig and scrap in piles higher than would be possible were hand labor employed, and thereby make more efficient use of the available space in the foundry yard.

Fifth. The ability to unload cars more quickly, and thereby save demurrage.

Sixth. The recovery of small pieces of iron in the bottom of freight cars, which can be magnetically swept up, but which would be neglected if the cars were unloaded by hand. This

FIG. 8.—MAGNET LIFTING NAILS IN WOODEN KEGS.

figure is considerable in the aggregate, and has been as high as several hundred pounds per car.

Seventh. The convenient recovery of nails and iron shot in foundry sand. This is accomplished by slowly passing the magnet above the sand and as close to the sand as possible, and as the magnet passes over successive portions of the ground, the small iron and steel particles, mechanically associated with the sand, will break through their confinement and leap to the magnet bottom, where they will be held until the magnet is de-energized.

Eighth. Independence of weather. This is particularly no-

ticeable in the South, where the negro is temperamentally opposed to cold weather, and where difficulty is sometimes encountered in getting the common laborer to work out of doors during cold and inclement weather. The magnet, if anything, lifts more on a cold day than on a hot one, and will lift pig iron when covered by snow.

Before discussing briefly the design and construction of magnets, it would probably be logical and pertinent to refer to the character of service which they encounter, and particularly

FIG. 9.—MAGNET LIFTING 16,000-POUND BLOOM.

to the extremely severe mechanical abuse to which they are subjected. For instance, a magnet, weighing about 1½ tons, is apt to be dropped, each time it is operated, onto a pile of unyielding pig or scrap iron, a distance of from 5 to 15 feet. This necessarily means that the magnet is subjected to hammering, and a series of impacts so terrific that it is not comparable with the service given any other piece of electrical apparatus. Magnets are almost always handled by operators utterly ignorant of electrical matters, and frequently their use has been regarded by laborers with open hostility, because of the fact that the magnets have made many jobs superfluous.

Bearing in mind, then, the extraordinary roughness with which lifting magnets are used, the necessity of sturdy design will be appreciated, and, indeed, it is true that many of the structural features are merely the response to the demands of hard service, and are therefore in the nature of natural evolution of design.

Briefly, the commercial lifting magnet of to-day consists of a disc-shaped steel casting, having in it an annular recess for the accommodation of the magnet coil, an energizing coil with many thousands of ampere turns to build up a magnetic field, suitable terminals for connecting the coil to the line, chains for the suspension of the magnet, and a non-magnetic bottom to hold the coil in its annular recess, to hermetically seal the bottom of the magnet, and to constitute a shield or a guard for the hammering to which the magnet bottom is subjected.

The steel shell must be made of special steel, soft and carefully annealed, so that the magnetic field can be quickly built up and quickly torn down. This steel shell should be ribbed over its entire external surface, to allow for the rapid dissipation of the heat which is generated in the coil. Coils, in general, are built up of strap copper, insulated by asbestos and mica, and wound on brass or aluminum spools. After the coil is completely assembled, it is thoroughly impregnated at a temperature of about 300° Fahr., giving the coil the best of insulation, and sealing it so as to exclude moisture.

An auxiliary device is the magnet control for quickly energizing or de-energizing the coil. For de-energizing the magnet, three different methods have been used: First, merely rupturing the circuit; second, opening the circuit, but allowing a discharge resistance for the inductive kick from the magnet, and, third, an actual partial reversal of the current. This last-named method is the one now employed, and will cause the magnet to release its load several seconds more quickly than by any other known method.

The question of safety is frequently raised, and during the time when the magnet was being commercially introduced its use was frequently combated on the score that it was dangerous to workmen. Of course, it cannot be denied that if a man is standing under a magnet that is carrying a load, and the circuit is

interrupted, something is going to happen to that man. The writer maintains, however, that it is safer to use a magnet for the transportation of material than it is to use chains, and for several reasons. First, the magnet is inherently a laboring-saving device, and when it is used the number of laborers in its vicinity is reduced, and frequently the magnet entirely displaces ground labor. Second, a laborer always looks upon a magnet with a high degree of suspicion, since there is nothing tangible to hold up the load, and he avoids getting under a load supported by a magnet more than he would under a load supported by chains; in other words, he uses more caution. Third, the accidental opening of the magnet circuit probably does not occur as often as the breakage of chains supporting a load.

PRODUCTION COSTS—A FACTOR IN SCIENTIFIC MANAGEMENT.

By Ellsworth M. Taylor.

Once again it is my privilege to address the members of the American Foundrymen's Association on this all important subject. And, in this instance, I do not intend to devote much time in detail to the elements of which correct foundry costs are composed. You have heard enough of these details in the past to be familiar with them. If you are not acquainted with them, I will be glad to put you in possession of the facts upon receipt of your personal request.

For our present purpose, therefore, I will simply restate the units which must be used by all foundrymen if the actual costs of castings are desired. This formula was adopted as standard several years ago by the Costs Committee of the American Foundrymen's Association, and it is still standard.

To obtain the actual cost of an individual casting or class of castings,

(1) Multiply the weight of the casting or class by the cost of the net metals consumed.

(2) Add the cost of the direct labor used.

(3) Multiply the weight by the per pound unit, covering all indirect costs to be distributed on a basis of weight of good castings.

These items are

Cupola costs,
Molding supplies,
Flask costs,
Core supplies and expenses,
(And all items of a similar nature).

(4) Multiply the direct labor by the percentage unit covering all indirect costs to be distributed as a percentage of direct labor.

These items are

Office and clerical charges,
Foremen, etc.,
Miscellaneous foundry labor and expenses,
Rent, etc.,
(And all items of a similar nature).

(5) Total the above amounts.
(6) Add a proper proportion of selling expense.

The total is the gross cost of the individual casting or class.

So much for the formula. Now to get down to my real purpose, which is to deal with this formula as incidental to modern business methods as applied to the foundry world. And I will begin with a question,

What is the greatest weakness of the foundry industry to-day from a commercial standpoint? Having had the privilege of looking into the inside workings of foundries in different sections of the country, I am forced to the conclusion that the greatest commercial weakness of the foundry industry to-day is lack of appreciation of sound business methods. And when I say this I mean primarily sound cost methods, because sound cost methods are to a manufacturing business what a man's heart is to his body.

I can almost hear some foundrymen say, "He's way off; the greatest commercial weakness in the foundry industry to-day is the labor problem." But is it? There is no intention on my part to discuss the merits of the labor question one way or the other. I am, however, well enough acquainted with the workings of the mind of the average foundryman to know that in the majority of cases he holds the labor problem solely responsible for his money losses and commercial weakness, when the fact is the question is only incidental thereto. Here is the situation, as I comprehend it, after a careful study of all the conditions.

The foundry business is, of necessity, local in its nature. With very few exceptions the foundryman cannot hope to secure regular customers, except within a limited area, the territory being determined largely by transportation facilities. The reason is, that when a customer requires castings, he wants them quickly. The long haul with its consequent freight charges and delays is

practically out of the question. The customer wants castings—not delays, and the foundry which gets his business must, to all intents and purposes, be located right at his back door. The result is, that if we study the map and statistics, we find groups of foundries located in the different sections within easy reach of the various manufacturing centers.

Now let us pick out any one of these sections and pay it a visit. Suppose we find there some half dozen foundries all doing a fair volume of business, and constantly in competition for new and old customers. Let us send out blue prints and specifications to the six and ask for bids on the same lot of castings. We receive quotations which vary all the way from two dollars and ninety cents a hundred up to four dollars a hundred.

We are a little bit surprised at the wide variation in the figures, but as we are on a tour of investigation, we decide to try again. So we send out more specifications, this time for a more difficult pattern. When the bids are received, the prices run all the way from four dollars a hundred up to six dollars a hundred. We had expected about this ratio of increase in the price, and we now list the prices on the two lots, believing we will be able on the question of price to give the two orders to the same man. But on listing the results we find the man who was next to the highest bidder on the first lot, is next to the lowest bidder on the second lot. In fact, taking the two sets of bids comparatively, only one man out of the six maintained any increase or decrease in the prices submitted, consistent with the relative value of the castings.

I have built up this hypothetical case to illustrate conditions which actually prevail to-day in more than one section or group of foundries. And what is responsible for them, labor conditions or lack of appreciation of sound business methods?

In analyzing the situation I will deal with three subjects:

(1) Materials,
(2) Labor,
(3) Indirect and burden items.

In regard to materials, I find that all the foundries in the group are about equi-distant from the sources of supply, that they

buy largely from the same general vendors, and that there is very little difference in the prices paid.

In regard to labor, I find that when compared with a section some five hundred miles or more away, the conditions are unfavorable. The men receive, perhaps, ten per cent. higher wages, and do not get out any more work. But when I compare the conditions in all the foundries in that one group or section, I find they all pay about the same wage rates, and get the same general average amount of work out of the men.

It is clear then, that so far as material costs and labor wages and conditions are concerned, all the foundries in the group are operating under the same general conditions, and we must eliminate these two factors in trying to account for any wide variation in bids for new business.

I next give attention to the surface conditions governing the indirect and burden items which obtain in the section, and I find that so far as net results go, it is a matter of give and take. Where one member of the group has the advantage in one direction, he has to give way to his neighbor in another. For example, foundryman number one may occupy a building located on a railroad siding. Foundryman number two may be several miles away from the railroad track, but located on the banks of a stream or river.

Number one has the advantage in truckage charges, in loading and unloading, but his landlord makes him pay a higher rent for these facilities. Number two is obliged to stand for his increased handling costs, but he pays less rent to his landlord, and his water power facilities go a long way toward evening matters up. And so it is with all the foundrymen in that section, where one loses the other gains and *vice versa*.

Thus, after taking a bird's-eye view of the situation in any one section or group of foundrymen, and having investigated the surface conditions which prevail from the standpoint of

(1) Material costs,
(2) Labor wages and conditions,
(3) Indirect and burden charges,

I am still in the dark and unable to account for the wide variation in the bids received for the two different patterns of castings.

It is clear then, that if I am to get at the facts in the case, I must dig below the surface. And I proceed to do this by meeting the several managers personally and asking them a series of questions.

To my query, "Do you know what your castings cost"? they answer unhesitatingly, "Yes," or "Near enough to be on the safe side."

"All right," I say, "I will admit you do, but now take a piece of paper and show me the method you used in arriving at the bids you gave me for those two sets of castings."

Then I begin to get what I am after. I learn they all use a fairly uniform method for arriving at the price of the materials and the labor and that they have the approximate cost of the metals, the molders' wages, etc., at their tongue's end, because these items are right before their eyes all the time, but when it comes to applying the indirect and burden charges, which are not held right up before them all the time, there is no uniformity of method at all.

And this is the information I get. One manager says, "There's the cost of my material and the labor. That's the weight of the casting, and I add a cent a pound to cover my indirect charges." Another says, "That's my labor and material cost, then I add four dollars a day to cover my overhead."

The next man states, "I take the cost of my material and labor and add fifty per cent."

Still another states, "Well, I looked the specifications over, and from my experience in the business, made up my mind I could make a profit on that casting at four cents a pound, and that's what I bid."

And, possibly out of the group of six bidders, there is only one manager who is able to produce a set of figures taken from the facts in his business, and who can justify his bid by these facts which he has put together in accordance with the units set forth in the formula stated in the beginning of this paper.

The remaining managers make frank statements as follows: "Why do I use a cent a pound? Well, down at that convention last year, I met the manager of the blank foundry and got to talking this cost business over with him and he told me they figured a cent a pound overhead, so I thought I'd try it."

"How did I arrive at my four dollars a day? Why, I hired

a foreman away from another concern and he told me his old company charged four dollars, so we've been doing it."

"What made me add fifty per cent. to labor and material? I met the cost clerk in so and so's machine shop and he told me they did that down there, and I thought what they did was good enough for me."

"Oh," I say, "but even if that clerk's figures are right, his company is operating a machine shop while you are in the foundry business." "I know that," is the reply, "but what's the difference?"

Here, then, at last, I have discovered the reason for the wide variation in prices and the inconsistency of the bids which I have received. And I find the great differences are due not to any tangible advantage in material costs, labor wages or conditions, or indirect charges, but to a complete indifference to, or lack of appreciation of, actual cost factors and units, which, in this instance, are representative of sound business methods.

I have before me the spectacle of a group of hard-headed, practical men, operating under the same general conditions, straining their backs in the effort to turn out a good product and make a fair profit, nearly all of whom are figuring their bids by some hit-or-miss method which not only endangers the permanency of their particular business, but affects the reasonable prosperity of all foundrymen in that section, and makes it a matter of luck if they do not happen to sell the product of the most efficient molder in their employ at a price which is actually less than cost. And which of these men is right? The man who has built up his figures in accordance with the standard formula which I have already stated. All the others are wrong.

I believe, gentlemen, that I have now substantiated my original contention, which is, that the greatest commercial weakness of the foundry industry to-day is lack of appreciation of sound business methods, as exemplified by careless indifference to proper cost factors and units of distribution.

The next step is to drive the facts home to your minds and make you see the absurdity and inconsistency of the position of those foundrymen who persist in defying these principles of sound business methods. And in attempting to do this, I will treat of one phase of the subject only, the indirect and burden charges,

illustrating my point by using an argument which I have presented in previous papers.

If we go into a manufacturing business of any size we will probably find that some of the employees are paid by the hour, some by the day, and some by the piece or premium system.

And if we go a little further we learn that there is some sort of a check on these labor items. We find that in some form or other a record is kept day by day showing the amounts to which each workman is entitled, no matter which method he is paid by. And in the case of piece and premium work, we sometimes find that there are several inspections, checks and counts made before the workman is given credit, although the sum involved may not amount to more than two or three dollars.

In other words, the manufacturer has come to believe that he cannot afford to *guess* what his payroll amounts to, nor what he gets for that money, nor who is entitled to it. In fact, he is so afraid that a ten-cent piece may go wrong, that he puts all kinds of checks on labor items of this amount to assure himself that it has really been earned.

But what does this same man do with his indirect and burden charges? He absolutely ignores them. He not only does not make any attempt to apply them correctly to his direct costs, but he does not even know what they amount to in dollars and cents. And he may tell us that he doesn't want to know, that it is too small a matter to talk about, that it would not make any difference to his business if he did know, that he prefers to *guess* at it that it might cost him some money to find out about it, and, in his judgment, all such matters are a waste of time, energy, brains and money.

This is the man, remember, who is so solicitous about the ten-cent pieces he pays his workman. Would he think the same way about the matter if he realized that in the average manufacturing business, for each ten cents paid to a workman for direct labor, an amount in indirect charges is consumed, varying according to circumstances and conditions all the way from ten cents to fifty cents, and in some cases even more?

In other words, if his direct labor payroll for one week is two hundred dollars, his indirect cost during the same period may have been from two hundred to five hundred dollars or more.

So if the manufacturer admits it is good business to have a check on the direct payroll, he must admit that it is decidedly "bad business" not to have a check on his indirect charges which in most cases equal or exceed his direct payroll. And he should realize that if he does not give proper attention to these indirect dollars, if he does not measure, weigh and count them at stated periods, just as he does with his payroll and bank balances, he makes it possible for dividends to slip through his fingers without ever being able to explain what became of them. Furthermore, there is no excuse for the man who ignores these facts.

Before closing, I want to call your attention to a group of four words which I will call the "secrets" of successful modern business organization, as they appear to me after having enjoyed the opportunity of a confidential insight into the workings of a varied number of enterprises. The "secrets" are:

Knowledge.
Simplicity.
Action.
Efficiency.

I will now proceed to define these "secrets" as I see them. Let us turn to the word Knowledge, as I am using it. By knowledge, I do not mean information about the article you are attempting to make commercially valuable. This kind of knowledge is, of course, essential and its possession is what leads men to go into commercial enterprises. It is hardly necessary to say that knowledge of the article you are commercializing is the foundation of the business, but when I have said that, I must stop, because that is all it is, the foundation, the part that is built below the earth's surface and on which the structure is to be erected. The particular knowledge to which I am referring may be described as "information of modern business organization," the superstructure, so to speak, the part which is to be built above the ground, and without which the foundation is of no commercial value whatever.

In a word, know what you are doing; know what you are getting for the money you invest in your business; know your men and their value to you. Study your superstructure, know all it contains. Do not deceive yourself in regard to it and make it

impossible for others to deceive you. Build this superstructure by a plan of up-to-date common sense. Know your costs of production. Line costs up so that the information will reach you promptly and will point out unerringly your weaknesses and leakages. Make the cost of your product include all the dollars actually invested. Then you are in a position to handle the situation without gloves, and not until then.

Disabuse your mind of the idea that all you have to do to make a commercial success is to be able to produce a good article. That is only the beginning. I have known of instances where the finest kind of workmanship and ability to produce good articles have been sold at a loss unwittingly because of ignorance of the kind of knowledge I am talking about.

I have known of other cases where the manufacturer has stayed awake nights trying to figure out how to do away with supposed leakages in certain directions, when the losses were afterwards proven to be imaginary or to be due to other unsuspected causes. Get your house in order; keep it in order; *know* what you are doing and why you are doing it, do not guess at it; that is the "secret" of the knowledge which I am trying to impress upon you.

And after knowledge comes "Simplicity." I will define simplicity as "the shortest distance between two given points." You will recognize this as the geometrical definition of a straight line, and to my mind, this "secret" of simplicity, "straight-line" simplicity, the shortest, most direct route between two given points in your scheme of organization is one of the greatest things in successful modern business organization. It means the shortest, simplest, most direct method for handling your orders from the time they are received until they are shipped, billed and the money collected. It means surrounding yourself with a series of straight lines. It means deadly directness.

Do away with duplication of effort, whether it is in the clerical entry of the order, the transmitting of information to and from your manufacturing departments, the loading and unloading of your pig iron, the handling of your patterns, the transporting of metals and supplies to your cupola and foundry, the pouring of the metal, the counting, weighing and ultimate distribution of your castings; never cover the same ground twice, never duplicate

effort, follow the rule of "straight-line" simplicity. And it is remarkable how these straight lines conceal themselves.

How easy it is for us to drift along unconsciously into ways and business methods, which are everything but straight lines. Nearly every manufacturing and mercantile business had a small beginning, and as the business grew it became necessary to substitute some other method for the "carry-it-in-your-head" idea. We could no longer content ourselves with shouting across the shop, "Say, Bill, Jones must have twenty of those castings tomorrow night sure!" There got to be too many Joneses and Smiths. The orders were getting well beyond our control. To meet the exigencies of the situation, we hastily got up a set of records and did the best we could. Finally, we needed more floor space, and other complications confronted us. Then we began to suspect that some of the work was costing more than we got for it. We began to look around to find out how the "other fellow" figured his costs. Perhaps he had looked into the question of costs more than we had, and was using some method which some one else had told him was right. Maybe it was a guess, maybe it wasn't. At any rate we decided to take a chance, and we tried a similar method. In this way we endeavored to meet each of our requirements individually and alone, and as they arose.

Thus we gradually built up a scheme of organization incapable of automatic expansion, many parts of which were individual units, instead of dovetailing into the unit as a whole, and finally we had successfully buried all these straight lines which were so anxious to make themselves seen.

This is the history of many a concern. Let us see to it that these straight lines no longer escape us. Aim for "straight-line" simplicity! Dig up the "straight lines," they are there. Go after them and use them.

And when you start to dig, and to use the principles of "straight-line" simplicity, remember that in every scheme of organization it is necessary to consider the average intelligence of the human element. Your straight-line simplicity must be made so straight and so simple that it can be grasped and operated by average intelligence, or it ceases to be the genuine, "straight-line" simplicity which I am describing.

And now I am going to describe the "secret" of Action. Action as I see it, and in the sense in which I am using the word, may be defined as a full realization of the importance and value of the "secrets" of knowledge and simplicity, and the putting into operation the principles which these two "secrets" embody. Realize the necessity for these things and see that they are accomplished; that is the "secret" of action.

I may now readily dispose of the "secret" of Efficiency. I will define efficiency as the art of controlling and regulating your entire organization by means of the results you get by using the principles I have described, as the "secrets" of knowledge, simplicity and action. This is to my mind the highest kind of efficiency, and what we should all strive for.

In closing, therefore, I simply wish to offer my apologies to the learned makers of dictionaries and geometries for playing fast and loose with their tools, and beg to assure them, that I have no desire to trespass further on their property, nor deprive them of a livelihood in their own particular fields of usefulness.

FOUNDRY CONSTRUCTION.

By George K. Hooper, New York City.

In the construction of foundries of such tonnages that handling methods must be carefully considered, the most important points to be determined primarily by the engineers are the characteristics as to weights, shapes, sizes, etc., of the product to be manufactured, the facilities for receiving and storing the raw materials, the shipping of the finished product and the routing of the various materials, and processes required in its manufacture.

The location of an industry is usually determined by one or more important factors over which the engineer may have no control, but which must be thoroughly analyzed by him, as these introduce conditions which should be anticipated early to avoid serious complications when the planning of the equipment and structure are undertaken.

Railroad or dock service, or both rail and water facilities, are, of course, an absolute necessity to the modern manufacturer, and the routing of the product, with reference to the location of these or the building of additional sidings or spurs to fit plant operating conditions, must be carefully planned.

After these preliminaries have been duly considered and digested, a definite plan of campaign may be mapped out to include such items as the locations of cupolas or furnaces with relation to the cheapest and most convenient method of handling iron, coke or coal for charging, and the facilities for taking away the molten metal for pouring, and the removal of the attendant refuse and waste. The layout of the molders' benches or machines should be considered with relation to the receiving of molding sand and location of pouring floors, which should, in turn, be contiguous to the cupolas.

The selection of a section to be devoted to the making, baking and storing of cores must also be assigned, which should be convenient to the molders, as the transporting of this more or less fragile material is a hand-labor item which we have not yet been able to supersede by any mechanical method.

If the foundry has a malleable department, the location of annealing ovens must be selected to minimize the distance of handling between them and the hard and soft cleaning mills, while the storage of packing and the filling and dumping of pots must be arranged to give the greatest service with the least amount of handling.

Another important item is the early selection of a system for the handling of miscellaneous materials. It will probably develop that some one of the well-known systems, such as hand-operated industrial cars, storage battery or steam locomotive industrial systems or monorail transporter systems will be chosen. Generally speaking, I am of the opinion that the overhead monorail system, which in combination with transfer cranes for covering specified areas makes a remarkably flexible arrangement, offers decided advantages over the others.

Although it has been pointed out that a crane aisle equal in width to the space occupied by industrial systems must be reserved for the operation of monorail systems, it is possible to utilize this space for hand trucking (and a certain amount of hand trucking and wheelbarrow work is unavoidable in any plant) without interfering with the operation of the traveler.

Then, also, the storage space for castings at cleaning mills and chipping and sorting benches, sprue cutters, grinders, etc., may be placed most conveniently to the operators engaged in this work, still allowing the traveler to serve operators beyond these zones without interference.

One factor decidedly favorable to the overhead system is that a plant may be laid out at several different grades to take advantage of material storage facilities, or to avoid expensive cuts and fills, the track level remaining uniform, and the difference made up in the length of the cables and the size of the winding drums.

The final determination of the selection of this system is dependent, however, among other factors of more or less importance, on the size and shape of the plant, the distance between points and the area of the zones over which the material must be transported and the variety of services to which it can be applied.

Following the selection of the general handling scheme, the

individual handling methods may be considered, and, whether they are for molding, sand handling and tempering, scale handling and storing or core conveying, each must be given close study and careful consideration as to the amount of floor space it is to occupy and the elevations of its various levels.

The number, size and characteristics of the cleaning mills, and their attendant exhaust systems, is a feature which may require some analysis before the location of these may be assigned, as will also the space required for the storage of flasks, bottom boards, spare parts, etc., and the lining and drying of ladles.

Should apparatus be installed for the reclaiming of iron from furnace slag and foundry waste, a space must be set apart for the storage of the slag and the disposal of the refuse resulting from this process.

If a department for the generation of electric power is required, the site may be selected by the usual rules applicable to industrial power plants. These rules hold good up to the selection of the current characteristics which should, for foundry work, be alternating, as the machinery operated in a foundry is almost invariably located in a dirty, dusty and sometimes inaccessible location. Heavy motors of the induction type should be used, as these are less susceptible to abuse and neglect than other types.

Current for operating cranes, which, with the nice control required for pouring small molds from large ladles, should be direct, may be obtained by providing an exciter of sufficient size to supply the required amount of current if current is being generated locally, or from a motor generator set if current is being purchased from a central station company.

The incorporation of these zones into the general scheme must be such as to give the greatest economic bearing, one on the other, relative to a direct and systematic routing of the product.

This outline gives, in a general way, a working basis, but even this must be flexible enough to vary somewhat as the detail design progresses, although when the selection of a scheme has once been decided on by careful consideration of each factor, independently and collectively, no radical departure should be entertained, as this leads to the destruction of the entire fabric.

Careful decisions in the selection and assignment of these

various processes, and the apparatus required by them, are imperative in a foundry, as this type of industry is one of the least flexible of the manufacturing plants, particularly if it be of the high-grade malleable type with large furnaces and ovens set on massive foundations, and provided with self-supporting stacks a hundred or more feet in height.

Thorough preliminary work also tends to cheapen the cost of the building structure, as, after the apparatus has been located, short roof spans may be adopted in certain cases, when building columns can be placed so as not to interfere with the equipment or operations. Conversely, large spans and heavy trusses may be used to avoid placing building columns in such positions as might increase the cost of the equipment and interfere with production. Although at times this adds materially to the cost of the building structure, it is chargeable only to the amortization account, while a row of columns which interfere with the handling of materials, or which sever the continuity of the routing of the product, would set up and maintain a perpetual charge against the cost of production.

Portions of the building over some types of apparatus, such as conveyors and high-bucket elevators, for instance, can be specially treated, leaving the rest of the building more or less standard, where, if the designing of the building is allowed to proceed regardless of special equipment problems, a large part of the building may have to be treated expensively, so as not to interfere with the special apparatus when these are finally decided on.

The building structure may be treated as an independent unit in the general scheme, after the modifying elements in the preliminary layout have been considered and decided, and their bearing on the building determined.

Although I have not attempted to give a detailed description of the machinery usually installed in a mechanical foundry, I think I have outlined enough to show that its application makes necessary extensive and fundamental changes in the type of building required for housing this industry.

In place of the single-storied building, with crane or cranes carried on columns or on side walls, with a light steel or wooden truss sufficient only to carry a roof of comparatively light con-

struction, we have a building of heavy and modern steel design capable of sustaining machinery loads of considerable weight, and of absorbing the vibratory stresses and shocks imposed by this equipment.

In cases where the product can be routed more economically by the adoption of multi-storied buildings, foundries of two or more stories are becoming common.

This type of construction is also being adopted where land values are high, and in cases where extensions are necessary to existing plants that are cramped for ground room. Although the adoption of modern construction entails a considerable amount of study and preparation, and adds somewhat to the cost of construction, this has been proven to be fully compensated for by the results obtained.

Preferably, in my experience, the structure takes the form of a steel skeleton with certain walls and masonry pilasters, concrete floors, metal sash windows, in some cases, heavy steel trusses supporting a roof of one of the acceptable forms of concrete tile now available.

For finishing and shipping departments on the ground floor of foundry buildings a tar-concrete base, carrying a Georgia pine rough floor with a finish floor of factory maple or beech, has given good satisfaction, while concrete floors present a good working surface for most operations which is beyond criticism.

In some cases, however, it becomes necessary to select special flooring to meet severe conditions.

For malleable foundries using mechanical charging trucks operated either by steam or compressed air, a flooring material embodying a wearing surface sufficiently tough to withstand the tractive effect of the driving wheels, as well as the necessary strength to carry the heavy loads transported by these machines, is required.

The hardest service succumbs rapidly to the slip of the driving wheels, and where steel plates have been used to protect the finished surface of the concrete they have been found to buckle badly.

Wooden paving blocks seem to offer so far the only solution and these, I can say from my own experience, make a very satisfactory flooring for this service. The expensive creosoted block,

such as is used for street pavings, is not required in foundry work, however, as a much cheaper type of block can be used which gives equally as good results. This floor can be laid up to within a couple of feet of the oven fronts, a good quality of vitrified paving brick being used to bridge the space between the refractory floor of the ovens and the block floor outside.

For a building of one story, devoted to floor molding, of course, no floor other than the suitable sand floor with pits is necessary.

The building walls are preferably of brick, and the columns supporting craneway and roof trusses should be built and well fitted into the masonry to save the expense of repainting. The roof trusses, and this should apply to all forms of buildings, whether single or multi-storied, should be constructed with heavy single web members, to facilitate cleaning and painting, and the construction of these trusses should be such that all parts can be reached easily for these purposes.

The so-called "Bethlehem column," or "H"-beam, offers advantages in that it saves built-up sections in some constructions, and saves, therefore, maintenance cost in cleaning and painting, with an absence of projecting rivet heads which collect dust.

The purlins require considerable care in aligning them to support the tile roofing, but this can be done quite easily with sag rods, even when the purlins are covering spans up to 18 feet.

Several excellent types of cement tile roof are now on the market, and these have some decided advantages over most other roofing materials for foundry purposes. The principal reasons for adopting this roof for industrial purposes are the facts that it combines strength and lightness, and that it is practically indestructible from natural causes, thereby tending to make the cost of maintenance exceptionally low.

A novelty embodied in this form of roofing is the glass inset tile, which appeals strongly to the foundry manager and engineer. It being a well-known fact that the molding department is particularly hard to illuminate, artificially, owing to the natural tendency of the dead black surface of the molding sand to absorb the light rays, the use of the glass inset tile makes possible natural overhead lighting, which extends the daylight period considerably without the use of monitors or heavy metal frame sky-

lights, both of which embody some very disagreeable features. As it has been proven by the practice of other engineers, as well as myself, that the inset tile is a more efficient lighting medium than the side-lighted monitor, we may as well dispense with this awkward and inartistic structure entirely and substitute for its ventilating features the hooded copper ventilator, several makes of which are so constructed as to induce a draft when a slight breeze is blowing from any direction.

Before the design of the steel work can be submitted to the contractor for estimates, the location of the machinery carried by the steel work must be decided on, and the weights, shocks, etc., determined. It is usually found that certain portions of the steel structure will be free from special loading, and these can be ordered and fabricated while the special work is being designed; as soon as these features are determined, the contractor for the foundation work can be notified to complete this part of the work first, thus keeping ahead of the steel workers, who, in time, make way for the bricklayers on the concrete form builders.

As soon as the steel work is completed in the special sections, the active work of erecting the conveying and other machinery may be started, orders having been placed for the purchase of this equipment while the design of the building and steel work was going on, the general contractor having in the meantime been supplied with information for the location and building of the machinery foundations, trenches, special floors, etc.

The roofing may be applied as fast as the trusses and purlins are placed and riveted.

When a foundry plant is under one roof, and covers a considerable area, the method of heating becomes a good deal of a problem, as certain zones must be heated to obtain the best results from the "rattler" tenders, chippers and sorters when their departments are located at some distance from sources of waste heat, such as cupolas, ovens, etc. Some heat is also necessary at night to avoid freeze-ups between the hours when the castings have been shaken out and cooled, and before the fires are started in the morning. In buildings not over 50 feet wide, direct radiation, placed on the outside walls, should be adopted, but in the wide building, covering a large area, it is obvious that this system cannot be used. For positively supplying heat to certain stipu-

lated portions of a building of this type, the hot-blast heating system seems to give the desired results, so far as the actual raising of the temperature is concerned, but the fact that this method keeps the dust in a constant state of suspension leads me to recommend the use of the *direct* system wherever practicable.

I have touched lightly on the subject of illumination under the head of roofing and monitors. For general illumination of pouring floors, rough and finished storage and shipping departments I have had very good success with the mercury arc lamp, although in some cases the 70- or 100-hour flaming arc has given better results. The field of usefulness of the 16-candlepower incandescent lamp is, however, but slightly encroached on by the large unit lamp in foundry practice, as I have found it necessary to provide for each molder, and over each unit of machinery, as well as at all benches, at least one small unit lamp, as well as furnishing a row of incandescent lamps spaced at proper intervals along the lines of conveyors. The liberal use of plug receptacles, placed handy to all machines and in all trenches and inaccessible places, is strongly advised, so that portable lamps may be attached by extension cords for the examination of and repairs to apparatus.

Although there is a large and increasing demand for the tungsten and metallized filament lamp, I am not yet convinced that these lamps are sufficiently rugged to stand the treatment which lamps in a foundry receive. The excessive breakage of the entire lamp in some cases, and the destruction of the filament in others, coupled with the high first cost of these units, far exceeds the saving obtained by the lower current consumption of the high efficiency lamps.

Under the heading of plumbing comes the question of water supply, toilets, wash rooms, drinking fountains, etc., and in this connection the problem of sewage disposal must be treated.

The subject of providing toilets for the rank and file of foundry employes is one of the most vexing problems for the engineer to solve. Although I think these men do not maliciously smash doors and closet seats, and rip chain pulls from their fastenings, they apparently become, through the labor that they are called on to perform, what might be described, for the want of a better term to describe their subconscious movements, "heavy

handed," which condition acts disastrously on even the heaviest plumbing fixture known to the trade.

The lifting closet seat is, of course, a decidedly unsanitary adjunct to the toilet room, and the heavy roll rim seatless closet is far more desirable from this point of view. The seat, however, has its advantage in that it can be used to operate the water for flushing the closet.

The significance of the flushing operation seems to be overlooked by most of the rougher class of labor, regardless of how obtrusively the chain pull is presented to them.

One of the most successful ways of solving all of the toilet room problems consists in detailing an employe to see that the closets are kept flushed and cleaned, and that no loafing takes place around them.

This method has its drawbacks in foundries covering a large area, however, as it is necessary in this case to scatter the toilets and divide them into small units, so that the men cannot have any excuse for straying away from the work on which they are engaged, as would be the case where one central location for toilets is provided. I am fully convinced, in view of these facts, that if toilets are to be provided for the more ignorant of the foreign labor classes, they must be kept under the constant surveillance of some responsible employe, or they become a continual source of expense and dissatisfaction.

The water supply for a foundry installation should be selected after considering the following factors:

Cost and quantity guaranteed by municipal or private water companies.

Availability of natural supplies.

Cost of utilizing this supply.

Quantity and quality obtained from natural sources.

Decision on this point is necessary before the water supply system can be laid out, which includes piping, pumps, tanks, tower, hydrants, hose houses, etc.

This is about all that can be said on this subject, except that I might mention here that foundry workmen are notorious wasters of drinking water, as their work causes them to become large consumers of this commodity, and their desire to have it cool enough to be palatable leads them to waste a great deal by allow-

ing it to run until all the warm water has been drawn from the pipes.

After some experimenting with more "fancy" fixtures, and a great deal of consideration based on the opinion of foundry superintendents and my own observations, I have concluded that a plain, copper-lined wash sink, provided with hand basins, chained in place, and supplied with hot and cold water, is the best method for washing, both from a cost and sanitary standpoint.

Shower baths seem to meet with an equal amount of favor and disfavor by the foundry managers.

Personally, I am in favor of installing them, as they not only increase the efficiency of the men in warm weather, but they also increase the self-respect of the men who choose to use them.

In this connection I might cite the case where several shower baths were provided which for a long time remained unused, much to the disgust of the manager, who considered he had conferred a favor on his employes by providing for their comfort. He told me recently, however, that a great many of his men now use them regularly, so it seems that the men will educate themselves to cleanliness, as well as other things, if means are placed at their disposal.

Another interesting case has been brought to my notice of a foundry which did not install showers "because the men would not use them." We had installed wash sinks in this plant some 8 feet by 3 feet wide and a foot deep. Several laborers, who deemed themselves in need of a bath, plugged up the drain, filled the sinks with water and crawled into them. These men were apparently of a higher type than most of their fellows, and certainly needed encouragement.

The departments that it is advisable to detach from the main buildings are the pattern shop, the equipment machine shop, the structure covering the oil storage tanks, if these are used, and, if power is being purchased, a building housing the high-tension switching apparatus and transformers.

By making the pattern shop an independent structure, we are able to erect a building having light on all four sides, and of a width which insures light at the machines; the best practice being to place these between the center aisle and the benches, which are, of course, located adjacent to the windows.

The pattern stock room may be provided for either above or below the manufacturing floor. If above, the lumber may be raised by a plain "cat head" hoist, large doors opening down to the floor being provided.

A very good arrangement is obtained by the combination of the equipment machine shop and the pattern shop under one roof. The building may then be of the multi-storied type, devoting the basement to the storage of heavy equipment materials, such as sprockets, heavy chains, pulleys, shafting hangers, motors, etc.

The first or ground floor is in this case the logical location for the equipment machine shop, which contains such machine tools as are necessary in the manufacture of flasks, metal patterns, core boxes, etc., consisting of lathes, planers, shapers, cold saws, drills of various kinds and such other tools as may be required to meet the demands of the foundry.

Space should be allotted in this department for a complete repair shop and the headquarters of the various repair gangs.

These are usually divided into millwrights, steam fitters and plumbers and electricians.

Each of these gangs should have sufficient space assigned it for benches and lockers, and the storages of chain blocks, rope falls, etc., with which they should be generously supplied.

An erecting space should be reserved on this floor for the setting up and repairing of large machines, charging trucks, etc., which are more conveniently repaired in the machine shop than in the works.

Frequently not enough attention is paid to the repair departments at the inception of an industry, although the maintenance of a plant is given prominent recognition in the estimated production costs. A properly equipped and organized maintenance force can be made to show savings, where production departments show earnings, and just as much care should be expended in the incorporation of this department in the general scheme as that of the molding floors or the power house.

Assuming that the basement and first floors of the combination building are occupied by the equipment machine departments, the pattern manufacture department should be assigned to the second floor, and as many floors added above this as are required for the storage of patterns, pattern stock, etc.

This building should be of fireproof construction throughout, and should meet all underwriters' requirements as to automatic doors, sash, etc. The floors should be connected by an isolated fireproof staircase and served by a platform freight elevator.

In conclusion, I would like to add that I have endeavored to emphasize the fact that the construction of a foundry, as is the case with all industrial plants, begins with the selection of the site, and every factor embodied in this decision has a certain definite and important bearing on the physical planning of the industry. The actual design and construction of the buildings are entirely controlled by this and the modifying conditions attendant upon the production of the commodity manufactured

THE PRACTICABILITY OF THE INDUCTION FURNACE FOR THE MAKING OF STEEL CASTINGS.

By C. H. Vom Baur.

The electric induction furnace for making steel has been in regular commercial operation in Europe for more than ten years, and more than thirty of these furnaces are in regular commercial operation there. It has now been brought to the United States in its improved form, which permits sizes of 8 to 16 tons' capacity, and 30-ton furnaces have been projected. These electric furnaces are of the Röchling-Rodenhauser induction and resistance type, operating on single-, 2- or 3-phase alternating current, utilizing any convenient voltage of commercial circuits; 25-cycle is preferred, but 60-cycle current can be used in the smaller sizes.

The furnace action is similar to any ordinary transformer. The primary coil, receiving the incoming current, is subdivided into series of steps, usually five, which, by the aid of a switch, regulate the current and consequently the heat in the metal bath. The secondary current is mainly (70 per cent.) induced directly in the bath, which is really one short-circuited turn of the secondary winding of the transformer (see Fig. 1). The remaining energy, 30 per cent., is induced in a large copper bar secondary winding, wound directly over the primary winding, which latter receives the electric current from the alternator. This auxiliary secondary current is carried to two steel pole plates, set beneath the lining, one at each end of the bath. The magnesite lining covering these plates is the hearth of the furnace and becomes the conductor of electricity when red hot, acting similarly to the filament of a Nernst lamp in this respect. There are, therefore, two sets of currents in the bath, the main or induced current and the auxiliary induced or resistance current. The advantage of having this combination of electric currents is manifold; it increases the thermal and electric efficiency of the furnace, increases the heat of the steel in the main hearth, thus facilitating the refining, and precludes any interruption of the current flowing through the metal. There are, therefore, no involuntary fluctua-

tions of the current, which is consumed at an absolutely steady rate (see Fig. 2). The heat of the metal can, therefore, be kept at any practicable temperature between a dull red and, say, 2600° C. (which is the limiting temperature of the magnesite lining). As there is no involuntary change in the current, and no violent fluctuations take place, there is no strain placed on the prime mover. In other words, in this type of furnace there is nothing to wear out but the lining, the furnace runs quietly and there are no carbon particles blowing through the air, owing to the method of melting the steel. The current, therefore, being steady, and the amount of steel in the furnace being known, the heat can, with a little practice, be accurately determined by observing the

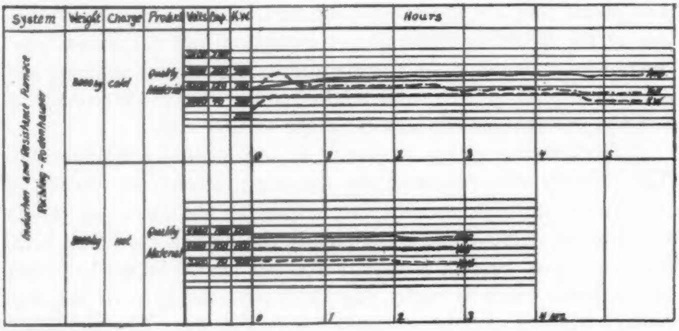


FIG. 2.—SHOWING STEADY CONSUMPTION OF POWER IN A RÖCHLING-RODENHAUSER ELECTRIC INDUCTION FURNACE.

ammeter reading. The heat regulation of a Röchling-Rodenhauser furnace is nearly perfect. This item, together with the simplicity of the furnace, and the fact that no foreign ingredients can inadvertently get into the metal bath; that is, no sulphur, no phosphorus, no carbon, nor any other substances from any flame, electrodes or lining, make the furnace most gratifying to operate. The furnace, even in a foundry, impresses one as being clean and almost noiseless.

The heat is produced only by heavy induced currents going directly through the bath, which allows superheating of the metal without the introduction of any oxygen or nitrogen. The metal, therefore, contains a minimum of gases. This reduces the ferro-

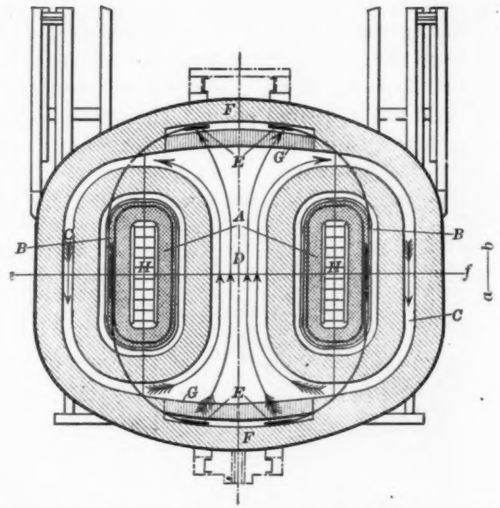


FIG. 1.—RÖCHLING-RODENHAUSER ELECTRIC INDUCTION FURNACE. C AND D INDICATE THE BATH.

FIG. 1*b*.—SHOWING LENGTH OF HEARTH.

silicon used and the ferro-titanium, if any. Contrary to the gas-heated or other furnaces or converters, the chemical composition and temperature can be regulated independently of each other. The composition of the metal can easily be changed and the temperature held at the desired point. The metal can be poured at the temperature to suit the conditions; for large castings, into crane ladles; for small castings, into bull ladles or small hand ladles. The furnace, being of the tilting variety, facilitates the

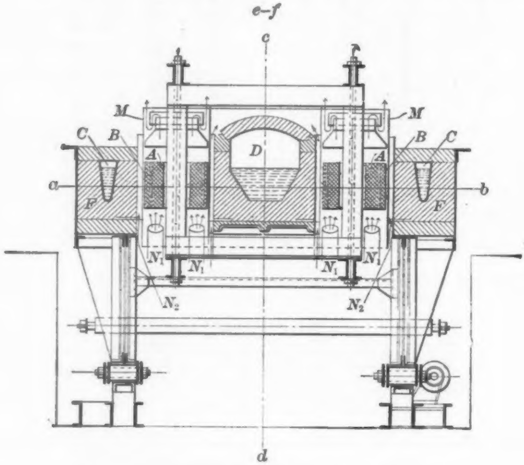


FIG. 1c.—SHOWING BREADTH OF HEARTH.

pouring and the removing of the slag by the rear door (see Fig. 3).

Cost of One Ton of Electric Steel in the Ladle.

The costs for making steel castings are essentially as follows:

Raw material {
1. The raw material.
2. The oxidation loss.

Conversion cost {
3. Electric current consumption and its cost per K.W.-hour.
4. Fluxes and additions.
5. Labor.
6. Tools, repairs, and lining.
7. Depreciation and interest.
8. Auxiliary apparatus (blower and tilting motors).

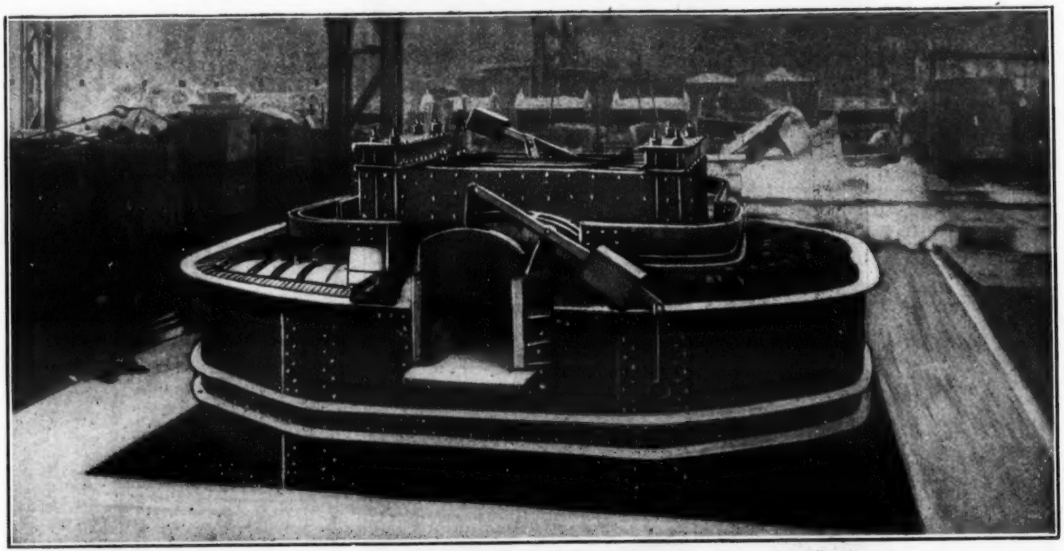


FIG. 3.—8-TON RÖCHLING-RODENHAUSER ELECTRIC INDUCTION FURNACE. 700 K. W. 4,000 VOLTS AT VÖLKLINGEN. (REAR VIEW.)

Two cases present themselves:

1. Cold charging.
2. Hot charging.

When charging cold materials for making steel castings, the cheapest steel scrap can be used to advantage and refined to the

FIG. 4.—ELECTRIC STEEL WORKS OF LE GALLAIS, METZ & CO. DURING CONSTRUCTION. MIXER IN FOREGROUND, ELECTRIC FURNACE IN REAR.

desired degree. The following makes a cheap and effective mixture:

¼ bundled scrap at $11.25 per ton	$2.81
¼ machine shop and heavy turnings at $9.25 per ton	2.31
½ old steel rails at $13.75	6.88
Total	$12.00
Oxidation loss, 5 per cent	.60
Total	$12.60

Electric current is being produced to-day for .6 cent per K. W.-hour with internal combustion engines, running on blast furnace, producer, natural gas or crude oil. The electric induction furnace provides a high load factor, operating, as it should, at full load for the greater part of the day. This continued operation insures this low cost for electricity.

The conversion cost per ton is, therefore, as follows (2-ton furnace with 280 to 300 K. W., operated at Völklingen):

	Per long ton.	
700 K.W.-hours for melting at .6 cent per K.W.-hour	$4.20	
200 K.W.-hours for refining at .6 cent per K.W.-hour	1.20	
		$5.40
Fluxes, etc.—roll scale 22 lb., lime 77 lb., fluor-spar 11 lb., sand 20 lb., ferro-manganese 8.8 lb		.44
Loss of fluxes owing to ¼ of all metal remaining in the hearth		.16
Labor, American equivalent, 2 to 3 men		1.50
Tools, repairs, and lining		.67
Depreciation 10 per cent., interest 5 per cent. on $11,300—300 days, 6 tons a day* = $1695 ÷ 1800 tons =		.94
Auxiliary apparatus (cooling air for transformer)		.04
Total		$9.15

Adding this, we get:

Raw material	$12.60
Conversion cost	9.15
Cost of one ton electric steel ready to pour	$21.75

To this cost must be added a slight license fee per ton, depending on the output:

Time of heat about 4 to 4½ hours.

When charging hot metal for refining or merely for thorough deoxidation and segregation, it may come directly from the blast furnace, from a mixer, a cupola or some other furnace.

* 12 hour day.

Several instances of hot charging follow:

Refining from Crude Pig Iron.*

At Dommeldingen very impure pig iron was charged into an induction furnace of the Röchling-Rodenhauser type and refined as follows:

	Analysis of charge. Per cent.	Analysis of cast. Per cent.
Carbon	4.0	0.5
Phosphorus	1.8	0.025
Sulphur	0.2	0.03
Manganese	...	0.76
Silicon	1.00	0.056

Duration of conversion, 5 hours.

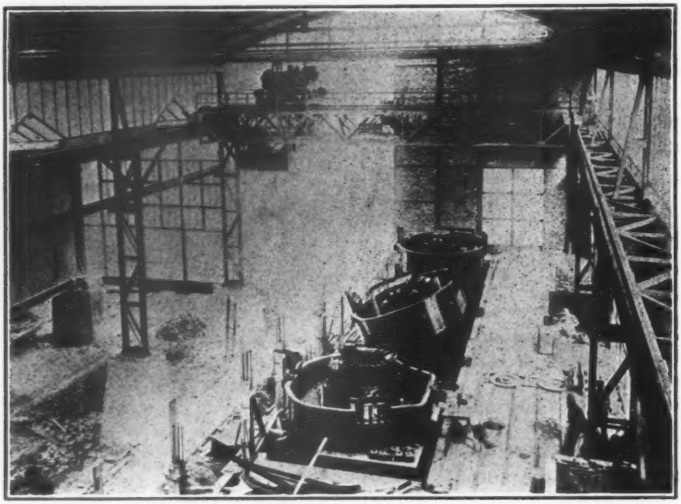


FIG. 5.—SAME WORKS AS FIG. 4. THREE ELECTRIC FURNACES DURING CONSTRUCTION.

Such impure hot metal is rarely charged in the electric furnace, except under unusual conditions, as it can be partly refined by a gas-fired furnace cheaper than in an electric furnace.

* See Transactions American Electrochemical Society, Vol. XV, 1909.

The cost of refining hot metal taken from the mixer at Dommeldingen, allowing for American conditions, is as follows for a 5-ton furnace:

Raw material	$12.00	
Oxidation loss 3 per cent	.36	
		$12.36
Current—280 K.W.-hours at .6 cent per K.W.- hour		1.68
Fluxes, etc		.60
Labor		.50
Tools, repairs, and lining		.64
Depreciation 10 per cent., interest 5 per cent. on $17,000—300 days at 40 tons a day* = $2550 ÷ 12,000 tons =		.22
Auxiliary apparatus		.06
Total		$16.06
Cost of preliminary refining, about		3.00
Total cost of one ton of electric steel ready to pour		$19.06

Time of each heat about 2½ hours.

The estimated cost of refining hot metal melted in the cupola, and consisting mainly of steel scrap, having about 2 per cent. carbon in the resultant mixture, is as follows:

Raw material	$14.00	
Total oxidation loss 8 per cent	1.12	
		$15.12
Conversion cost similar to the above		4.90
Cost of preliminary melt in cupola, about		3.00
Cost of one ton of electric steel ready to pour		$23.02

Time of each heat about 3½ hours.

Under ordinary conditions there is no very great difference in the total cost of hot metal ready to pour into the ladle, when charging either hot or cold material. The discrepancy is in the output. With a 5-ton furnace it is as follows:

	Per Month.	
	Single turn tons.	Double turn tons.
Cold charging	235	470
Hot charging	500	1000

* 24 hour day.

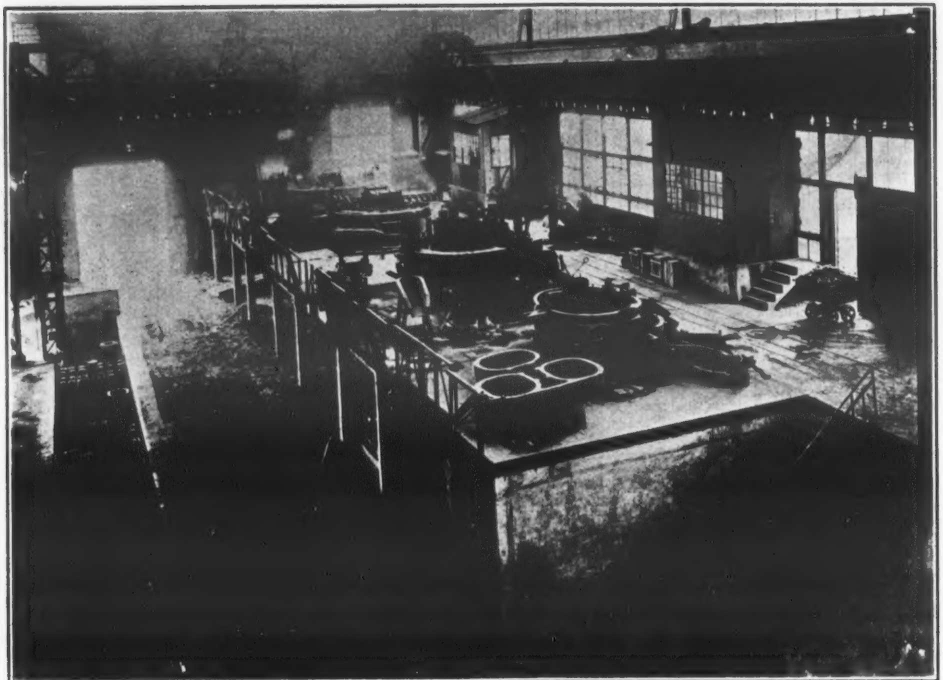


FIG. 6.—SAME WORKS. FOUR ELECTRIC FURNACES ALMOST COMPLETED: TWO OF 4 TONS EACH, ONE OF 2 TONS AND ONE OF 1 TON.

It is evident that the electric current, and all the machinery it entails, does not enter largely in the total cost of a casting. It is usually not over ¼ of a cent a pound, or as little as 5 per cent. or even 2 per cent. of the selling cost of the finished product. From the foregoing costs, it follows that steel can be melted in the electric furnace for $4.20 in a 2-ton furnace, and for about $3.50 in an 8-ton furnace with electricity at .6 cent per K. W.-hour. At the same time, though, the output is decreased by about one-half, as indicated above, for two reasons:

1. It takes longer to treat cold metal than hot.
2. We only pour three-quarters of the capacity of the furnace when charging cold material, instead of the total contents of the furnace when treating hot material.

(When charging cold metal, a little of the hot charge remains in the furnace to complete the electrical circuit. Cold scrap being in many pieces, does not meet the conditions, as the voltage in the bath being as low as 2 or 3 volts, is not sufficient to overcome the contact resistance between these many pieces.)

Quality of Electric Steel.

The above costs cover a quality of steel as hereinafter mentioned, and made from the various impure raw materials. The metallurgical course of the process is very similar to that employed during the refining period in a basic open-hearth furnace. The limestone and roll scale are charged and the bath is then refined until the analysis shows that no phosphorus remains or the process may be stopped before this, thus retaining some phosphorus and cheapening the process. This refining usually lasts an hour or so, varying somewhat with the initial percentage of phosphorus present. During this dephosphorizing period the carbon is greatly reduced and the silicon entirely or almost entirely eliminated. This first slag is then thoroughly removed by tilting the furnace backward at a slight angle and rabbling off the slag. Then, according whether mild or hard steel is required, a quantity of carbon is added to meet the requirements. At this time sufficient ferro-manganese is charged to meet the specifica-

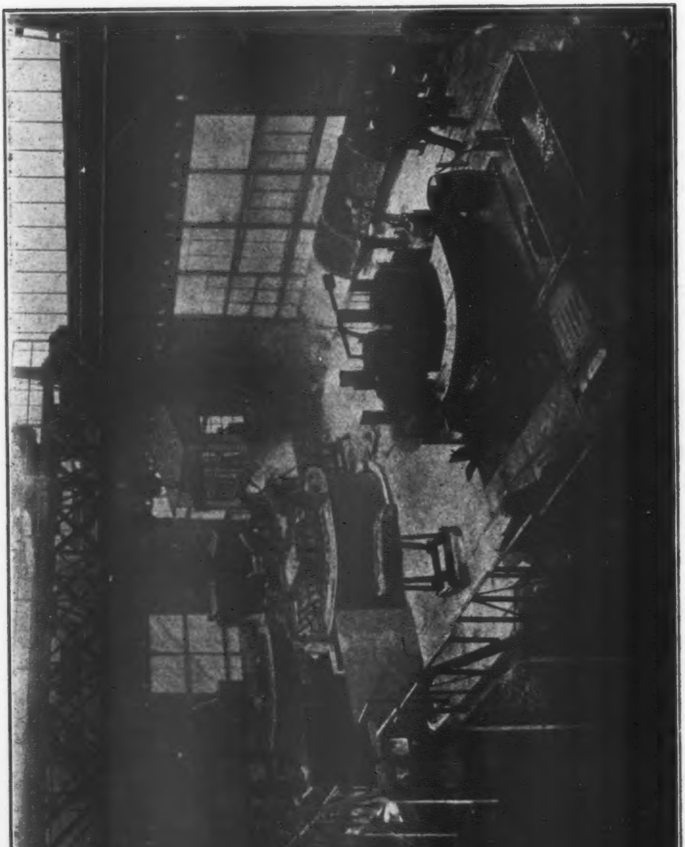


FIG. 7.—CHARGING A 4-TON FURNACE WITH MOLTEN METAL. (NOTE THE MEN STANDING ON THE FURNACE.)

FIG. 8.—TAPPING A 4-TON FURNACE.

tions. The desulphurizing slag is then added. As soon as this is melted, the bath and slag are deoxidized, the slag becomes white, and, owing to the now increased temperature, absorbs the departing sulphur rapidly, the refining being dependent upon the temperature at the point of contact between the metal and the slag. The gases are now expelled and likewise the small particles of slag which are brought about by deoxidation; in the same manner the sulphides are absorbed by the white lime slag while a small part of the sulphides volatilizes; otherwise the composition of the bath remains the same. Carbon is then analyzed for and the necessary modifications made. In the case of alloy steels, the alloys are only added after the deoxidation period, so that any loss which might be caused through the formation of slags is avoided. This deoxidation period usually lasts an hour. It is this deoxidation period, so thorough and effective, which has no parallel in any gas-fired furnace or converter. The sulphur has meanwhile almost entirely disappeared, getting as low as .01 per cent. to .005 per cent. After a last analysis shows that the deoxidation of the metal is complete, the furnace is tapped without any additions of any kind. Castings of any intricacy from ½ a pound to the capacity of one or more furnaces are regularly made. In one of the works of Luxemburg, from which the following figures are taken, four grades of steel for castings have a call:

Grade.	Tensile strength. Lbs. per sq. in.	Elongation. Per cent.
a	56900 to 64000	25
b	64000 to 71000	20
c	71000 to 85400	15 to 18
d	85400 to 99600	8 to 10

For the electrical industry, a particularly soft steel of the following analysis has a market:

C %	*Si %*	*Mn %*	*P %*	*S %*
.05 to .06	traces	.20	.005	.003

In the following table, No. I, the chemical analyses of various steels are given:

TABLE I.

No. of charge. Quality.	C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.	Cr. Per cent.	Ni. Per cent.	W. Per cent.
1458, very mild, for welding	0.04	traces	0.24	0.006	0.007			
1406, mild, for case hardening	0.18	0.16	0.62	0.009	0.009			
1692, for building of machines and wagons	0.45	0.20	0.62	0.011	0.008			
1738, for building of machines and wagons	0.61	0.20	0.71	0.006	0.010			
1413, mild tool steel	0.62	0.14	0.27	0.006	0.008			
1554, medium tool steel	0.81	0.20	0.27	0.008	0.008			
1680, hard tool steel	1.05	0.18	0.24	0.010	0.009			
1638, very hard tool steel	1.23	0.20	0.23	0.008	0.009			
1654, chrome steel	1.03	0.17	0.23	0.009	0.007	1.35		
1242, nickel, case hardening	0.21	0.14	0.51	0.012	0.010	....	3.77	
1583, nickel steel, for fabricating	0.33	0.20	0.36	0.009	0.010	....	3.06	
1509, chrome nickel steel, for case hardening	0.12	0.20	0.29	0.011	0.010	0.91	3.93	
1292, chrome nickel steel, for fabricating	0.34	0.17	0.32	0.005	0.011	1.23	3.51	
1302, special spring steel	0.57	1.53	0.44	0.004	0.011			
1300, special tungsten steel	0.55	0.50	0.21	traces	traces	1.00	....	0.60

Below, in Table II, some of the physical tests are given of the steels of Table I.

TABLE II.

Heat No.	Elastic limit. Lbs. per sq. in.	Tensile strength. Lbs. per sq. in.	Elongation. Per cent.	Reduction of area.
1458	31,300	43,400	35.4	70.0
1406	44,100	69,400	26.5	54.6
1692	61,150	96,580	20.2	42.0
1738	70,250	114,360	15.0	35.6
1242	54,600	76,100	23.5	64.0
1583	65,130	86,760	21.9	50.0
1509	64,560	83,900	22.3	64.0
1292	104,680	123,740	13.3	48.0
1302	68,260	112,640	15.2	43.0

The data regarding the physical properties and chemical composition of the steels produced might be of further interest, and Table III is, therefore, given, which shows some chemical and physical characteristics of annealed steel castings. The physical tests were made from irregular-shaped castings. The table follows:

TABLE III.—RESULTS ON ANNEALED CASTINGS.

Heat No.	C.	Si.	Mn.	S.	P.	Tensile strength. Lbs. per sq. in.	Elongation. Per cent.
385	0.12	0.13	0.53	0.014	0.011	51,920	22.5
368	0.10	0.20	0.48	0.015	0.020	58,000	23.5
704	0.23	0.30	0.50	0.021	0.025	66,840	24.0
705	0.26	0.31	0.62	0.018	0.022	68,550	20.0
707	0.32	0.35	0.83	0.012	0.025	79,650	20.5
734	0.35	0.32	0.68	0.022	0.023	85,340	15.5
816	0.37	0.35	0.71	0.009	0.017	95,300	15.0

Relative to the resistive power of electric steel to acids, or the weather, a series of comparative tests have been made by using a modified apparatus as that proposed by Prof. K. Arndt. The test pieces were polished and placed in hydraulically locked glass bottles, provided for the purpose. The quantity of air or oxygen absorbed by the iron was thus easily determined by means of a vertical gauge. The results of these tests are given in Table IV.

TABLE IV.—RESISTIVE TESTS OF VARIOUS STEELS IN ACID.

			After 4 days.	After 7 days.
Test 1.	Muriatic Acid	Electric steel	2.71%	4.50%
		Open hearth steel	4.62%	6.67%
		Bessemer steel	13.82%	21.30%
Test 2.	Muriatic Acid	Electric steel	1.31%	3.50%
		Open hearth steel	2.98%	5.00%
		Bessemer steel	6.47%	12.90%
Test 3.	Muriatic Acid	Electric steel	1.53%	3.00%
		Open hearth steel	3.70%	6.92%
		Bessemer steel	6.00%	11.62%
Test 4.	Sulphuric Acid	Electric steel	3.73%	7.21%
		Open hearth steel	8.41%	16.76%
		Bessemer steel	13.86%	24.73%

In each test three pieces of equal weight, brightly polished, were used, one of electric steel, one of open-hearth steel and one of Bessemer steel, of similar chemical analysis. These were placed in the acid solution and showed the losses as given in the table. It appears from this that electric steel is also in this respect a first-class material, and it may lay claim to incontestable preference wherever materials have to be furnished to meet the strictest specifications. The fact that electric steel has

been accepted to such a considerable extent in nearly every industrial application is explained by its prominent qualities. Electric steel is unequaled in homogeneity, density and facility in working. The Röchling-Rodenhauser furnace materially aids the production of this, because in the manufacture of steel the bath is not contaminated as is the case in any other furnace equipped with gas heating or heat applied in other ways, and this feature, together with the suitable control of the heat becomes of great importance when impure material is to be ridden of its sulphur, phosphorus and gases.

OPEN-HEARTH STEEL FOUNDRY PRACTICE.

By R. A. Bull, Granite City, Ill.

The manufacture of steel castings from the open-hearth furnace has been accompanied with such remarkable progress in the last fifteen years, and has reached such a commanding position in the foundry world to-day, that it provides a topic of very general interest, and one that should be fruitful in the matter of discussion. It is obviously impossible to cover the subject more than briefly in a paper such as this and I shall confine myself as nearly as possible to a cursory treatment of some of those questions of operation which are of particular interest to all foundries making open-hearth steel. In so doing, I beg to assure my respected colleagues that I make no claims for originality or infallibility in what I have to say. An experience of eleven years in this branch of the foundry industry has taught me better than to make such a youthful error.

Melting.

It seems hardly necessary to consume much time with a detailed description of furnace construction. However, by way of introduction it will not be amiss to explain for the benefit of founders of other metals than steel, that the two types of open-hearth furnace—acid and basic—are of the same construction except for the material used as a bottom. The furnace is of the regenerative type, and has a rectangular shape, with a shallow bath, the fuel being introduced intermittently from each of the two ends or ports. Natural gas, artificial gas, fuel oil, or crude oil provides the fuel, and where oil is used, it is atomized by compressed air or by steam or sometimes, by both. Where the furnaces are sufficiently distant from the boilers to condense much of the steam, it is advisable to superheat the latter before it enters the burner. The drier the air or steam, the better will be the atomization. It is not a difficult matter to make the furnace superheat its own steam by means of a coil set into the flue,

either on the furnace or the stack side of the valve. When ordinary pipe is used for this purpose, valves should be provided at the inlet and outlet of by-passing through the coils, so that the supply line containing the wet steam can be depended on, should the coil burn out.

The roof of the furnace is, of course, arched. There are many differences of opinion concerning this seemingly simple feature, and these arise from the disastrous experiences had with some forms of roof. It is a serious matter to have the roof fall into a charged furnace, and this may be due to defective construction or careless melting. Some roofs are constructed with a sort of downwardly projecting baffle near the ports, to deflect the flame to the bath. This object is attained, I fear, at the expense of cutting out the roof and causing it to cave. Certain roofs are sprung in both directions, horizontally and transversely. I favor the straight type of roof, that is, one having the same radii, without projections from port to port. And since the furnace is always hotter on the tapping side than on the charging side, due to loss of heat through the charging doors, causing the roof to burn out more quickly near the back wall, it has been found worth while to make the roof at this point 13 inches thick, tapering gradually to 9 inches, and obtaining this graduation by special silica shapes. Of course, the radii of the inside of the roof are made identical, the difference being on the top or outside. Great care is exercised when lighting up a new furnace, in properly loosening up the tie rods for graduated and uniform expansion of the roof, to avoid buckling, and so ruining what may have been a perfectly constructed roof.

As with the roof, so with the checkers and the stack is it advisable to provide more generously for the foundry than for the mill and all for the same reason; namely, because of the higher working temperature, generally speaking. With a properly designed roof, well constructed, with ample checkers and with a high stack of suitable diameter, given careful manipulation by the melters, and the use of first-grade brick throughout, a basic stationary furnace fired with oil should turn out 450 heats for the foundry without more than the usual Saturday or Sunday repairs. The acid stationary furnace should make 600 heats. The gas-fired furnace of either type will not last so long, because

it is not possible to so nicely control and direct the flame as with oil. The tilting furnace naturally suffers displacement of its brick by rolling it in tapping and its life is very short. It has some advantages over the stationary furnace, but these are not generally regarded as balancing the inferiorities.

I beg to express my opinion that insufficient attention has heretofore been given by most of us to proper atomization in the oil burner. There are various patented burners on the market, but those of proper proportions for open-hearth practice are quite few in number, and most furnaces are equipped with "home-made" atomizers. It is, however, only by the use of considerable skill, the acquisition of much experience, and data compiled from carefully conducted tests, that a thoroughly satisfactory burner can be produced, except by mere chance.

Probably one reason for the partial neglect of this feature hitherto has been the difficulty of metering the oil consumed. I believe it to be less than two years ago when it was impossible to secure a meter that would register closer than 12 per cent. of accuracy on fuel oil. Since that time meters have been put on the market guaranteed to register within a permissibly narrow limit, and this has undoubtedly stimulated the investigation of the most economical burner. And in connection with the proper atomizing of the oil, aside from the mechanical construction of the burner, I offer it as my belief that a recording thermometer is an excellent device for the oil pipe line. Furnacemen know that fuel or crude oil will not atomize well if either too hot or too cold. And the use of a recording pressure gauge on the oil line and one on the air or steam line are wise investments. By such means, experiments will show what temperature and pressures give best results, the readings will show any undesirable fluctuations and the causes for these can be easily remedied. An automatic recorder, to register the reversing of the burners, which should take place at approximate intervals of twenty minutes when the furnace is charged, and thirty minutes when empty, prolongs the life of the furnace.

As to the differences in construction and operation between the acid and the basic furnace, these are more easily disposed of than are the relative advantages of the two practices. The acid bottom is made up of silica sand, while the basic furnace has a

bottom of magnesite, or a mixture of magnesite and some basic slag. Additional sand is used for repairing acid bottoms, and magnesite or dolomite for filling up the holes that develop in the basic bottom. The acid furnace is not capable of the reduction of phosphorus and sulphur and consequently necessitates the use of pig iron and scrap of low content in these metalloids, for the conversion into steel of high grade. Carbon, silicon and manganese can be reduced easily in the acid furnace, and for the reason that its process is not such a refining one as the basic, its heats can be made more quickly and with less damage to the brickwork.

The basic furnace permits the use of charges containing high phosphorus and moderately high sulphur, for these elements, as well as the three reducible in the acid furnace, can be worked down to permissible percentages for first grade steel. Naturally such refinement consumes more time and reduces the number of heats capable of being tapped without repairs to the furnace. This refining process oxidizes more metal than does the acid process, causing a higher melting loss, at the same time, charging the molten bath with more gases, which should be practically eliminated before casting. This, of course, calls for the use of proper deoxidizers, concerning the addition of which much has been learned in the past few years. Melting losses in the basic furnace average close to 9 per cent., while those in acid practice are generally claimed not to exceed 6 per cent.

There is yet considerable difference of opinion as to the relative qualities of acid and basic steel castings, though not a few acid enthusiasts of yesterday are being converted into basic advocates of to-day. Concerning the relative economies of the two processes, it is largely a question of locality and the prices of delivered suitable raw materials. But for superior castings, which must be not only practically homogeneous, but capable of withstanding severe shocks and strains, I champion the basic process, in the face of contrary opinion held by a few eminent metallurgists and sustained by many steel founders in the Eastern States. I do not believe that the views, held by those who decry the basic furnace because of its difficulty in producing solid castings, have been formulated with sufficient knowledge of what has been accomplished by basic steel makers in the past

six or seven years. It should always be borne in mind that the superior refining possibilities of the basic furnace are clearly exemplified in the product and this means much to those whose need is for steel castings containing a minimum of the objectionable elements, and whose purse will not provide for the necessarily high price charged for crucible or electrically smelted steel castings. Our basic melters are entitled to much credit for great recent advancements in this direction and they have been ably assisted by the manufacturers of various alloys. Let no one, however, so mislead himself as to accept, without question, all of the extravagant claims made for such alloys by most of their selling agents.

It is, I find, not known to all acid steel founders, familiar with basic melting or to all consumers of steel castings and metallurgists, that there are numerous steel foundries that for several years have made it a practice not to pour the last part of the basic heat in castings intended for purposes calling for practically homogeneous metal and steel which will successfully withstand severe shocks and strains. There is an undesired increase of phosphorus and sulphur and a disappointing decrease in manganese and silicon in the last three per cent. (approximately) of most heats which carry a normal thickness of basic slag in the ladle. These changes in the analyses are of sufficient degree to cause trouble if such metal be converted into castings such as are referred to above. It is no uncommon sight to witness the pouring of this inferior metal, in steel foundries wishing to maintain a high reputation for the superiority of their product, in ingots or pigs, to be used only as are crop-ends in the mill. The slag while serving as a conserver of heat is principally responsible for the deterioration of the metal lying just beneath it. Experiments have been made, but so far as I know, without complete success, at least in the plant with which the writer is associated, to dispense with the basic slag after tapping the furnace and to substitute for it some other covering which will prevent the chilling of the steel, and at the same time not affect the elements in combination. The chief difficulty is found in mechanically removing the slag, which must be done with promptness and thoroughness in the face of decidedly awkward and physically unpleasant conditions. Notwithstanding such

handicaps, the possible results are of sufficiently great importance and economic value to justify continued application of ingenious effort in this direction.

I prefer not to leave the topic of melting without briefly advocating for humanitarian and economic reasons, three eight-hour shifts on the open-hearth platform. I firmly believe man to be incapable of his most efficient physical and mental labor prolonged for twelve hours per day, and for seven days per week, in the face of such trying conditions as are those of a furnaceman, especially during the hot months of the year.

Pattern Making.

Having given perhaps more than sufficient time to furnace discussion permissible in the proper limits of a paper on such a broad subject, our next natural topics for description will be the foundry and its sisters, the core room and pattern shop. Regarding the latter there is not much to discuss which is characteristic of open-hearth steel plants, and yet of common interest to all of these. I wish by no means to give the impression by this statement that the pattern department, in my opinion, is comparatively an unimportant member of the works' organization. Its function is not to be overestimated and goes far beyond the cheapest method of constructing patterns which *can* be used for making castings. The strength and type of patterns are regulated by the number of castings ordered and the most economical method of producing them. And since many open-hearth plants daily make castings varying in weight from a few pounds to several tons, on orders calling for one casting to several thousand, it can be readily appreciated that the variety of work necessitating diversity of methods, gives ample opportunity for the ingenuity of the pattern foreman, whose experience must be broad enough to adapt the construction of the pattern to the job, whether the material used be white pine, maple, redwood, mahogany, gray iron, brass, aluminum, or what not, and to intelligently make the proper shrinkage and warpage allowances, greatly varied as they are in steel work.

While dealing with the subject of patterns, I do not like to pass to the next one, before suggesting to those whose work is

of such a nature as to permit its extensive use, and who may be partially unaware of its adaptability, the enormous possibilities of the covering-core pattern. I think its value is greatest in the open-hearth foundry because of the increased difficulty there in preventing scabs and strains with large copes, in casting. "Covering core" is really a misnomer, but the term is used for want of a better one, and at least readily conveys its meaning to foundrymen, to whom the principle is not new. I do not believe any one, who has not seen for himself with what reduction to foundry cost this use of a copeless mold can be economically applied, can fully realize its advantages. Naturally its usefulness is largely confined to designs with large area and open spaces between top members of small or moderate width, all without great variation from the same horizontal plane. I have in mind a certain intricate casting which occupied a floor space over-all of about 120 square feet and weighed only 3,300 pounds. It required one nine-hour shift and five hours of the succeeding shift for eight molders and five helpers, or equivalent of about twelve and one-half molders and seven and one-half helpers to make one mold with cope and drag. The use of the covering core later for this same job permitted the finishing of two molds (and, by the way, much better ones, resulting in a lower piece-work rate for chipping the castings) by twelve molders and six helpers in one nine-hour shift. The piece-work cost for labor in making the covering cores for one mold amounted to $1.80. As the cost of core rods, core sand, baking cores, etc., is more than offset by the cost of facing, gaggers, and such materials in the cope, the proportion in favor of the covering core in this case is as two to one. Additional advantages are the elimination of crane service for handling large unwieldy copes, and the reduction of floor space required on the molding floor.

Molding and Core Making.

It is, of course, generally known that silica sand of about 97 per cent. purity is the material required for both mold and core, in the case of the former being mechanically mixed with such ingredients as fire clay, molasses, glutin, water, etc., and in the case of the latter, with the above mentioned substances and flour,

oil, dry core compounds, etc. Attempts have been made to produce permanent molds for steel castings but with very little success, and the field for usefulness here seems to be exceedingly narrow. Unobstructed by corners or angles, cast steel will shrink 5/16 inch per foot, and this excessive contraction is the apparently insurmountable barrier before the ready adoption of the mold which will maintain its form in shaking-out.

Up to about fifteen years ago, it was not believed possible to pour steel in molds not thoroughly dried and secure castings much less porous than a sponge. The West was the pioneer in experimentation here as in many other problems of the steel founder and demonstrated this to be a fallacy. As a matter of fact, while a perfectly dry mold will produce a more homogeneous casting than will a green mold, the specific gravity of castings made in green sand, not skin-dried, is found by very careful experiment to be only 4.3 per cent. less than that of steel castings poured in well baked molds. While it is always the desire of the customer and the ambition of the founder to secure castings of perfect homogeneity, and each knows that a well dried mold is necessary for such purpose, nevertheless there are many cases in which it is quite impossible to properly provide for natural contraction of the cooling casting without resort to green sand for mold or core. In such instances it is manifestly wise to sacrifice the four to five per cent. of greater density by producing a casting free from shrinkage cracks, some of which are not always observable on the surface. For this reason the use of green sand in steel molding has its very important applications. Portable oil burners are successfully resorted to as skin-driers for molds not of convenient size and conformation for thorough oven-baking.

The preparation of the facing and core sands is all important and is mechanically performed by methods sufficiently well known to require no description here. The mixtures, however, deserve a few remarks by the way. The character and amount of bonding material varies necessarily with the quality of the sand available and with the degree of thoroughness with which the mixing is done. It is usually found highly economical and eminently satisfactory in every way to use a large percentage of old sand in the facing and core mixtures, many foundries using

50 per cent. of such old sand and some a larger amount, though I know of steel foundries where all of the old sand is consigned to the refuse cars, extravagantly, as I believe. However, the amount of old sand best to use, depends somewhat on the nature of the work to be produced and the amount of fire clay or other bonding materials necessary varies as the percentage of old sand varies, since the latter carries clay or other bonds in greater proportion than does the ordinary silica sand as found in nature.

In large foundries an economical method of recovering and handling this black or old sand is by the use of a lifting magnet and a grab bucket. The magnet is used to wash the floor, so to speak, and take from it the spills, gates, raisers, etc., after which the clam-shell bucket follows to pick up the sand a yard or two at a time and dump it in the storage bin.

It is well to provide very generously in the way of sufficient dry pans or other mechanical mixers, to make possible at all times and in spite of occasional breakdowns the thorough mixing of the facing and core sand, so that suitable strength of each can be secured with the minimum amount of bonding material.

Since molding methods are in their essentials, practically the same for all metals, we will only give attention to certain of these methods, peculiar to open-hearth steel foundries. For bottom pouring, necessary for such foundries, it can be understood by those who have never had experience with the manufacture of steel, that the mold must be rammed very hard, to avoid straining and breaking out under the pressure of the stream from a large ladle. For the same reason, the flask must be very strong and rigid and the closing of the mold attended with every precaution against "run-outs." Because the mold is rammed hard, reducing to a minimum the voids between the globules of sand, ample vents must be suitably placed to permit the escape of gases in pouring; and to satisfy the high shrinkage common to steel, risers or sink-heads of sufficient number and size are provided. These risers are sometimes kept molten for feeding purposes beyond their natural freezing point by the use of stirring rods, charcoal, or thermit.

In labor saving devices for making the mold itself, the jolt-ramming machine is easily the leader in the open-hearth foundry, and is being made more and more flexible in its applications to

diversified work and peculiar conditions. Its operation is very familiar to all foundrymen, and to those in the open-hearth field it appeals strongly because of its peculiar advantages here, where hard, uniform ramming is essential.

Because of the severe pressure of the molten metal on the mold, cores of various kinds for the open-hearth steel foundry must be better reinforced with rods than those used for other metals, to avoid springing, and they must be more collapsible than those used in the gray iron foundry, because of the excessive shrinkage. For this purpose, sawdust, coke, cinders and the like are frequently resorted to, and the dry core compounds are of great benefit, since they enable the preparation of core sand having the requisite bonding strength, at the same time making the core less refractory than does flour.

It is the customary practice to fire the core oven with coke, but careful and intelligent experimentation with an oil burner under the cores will, I think, convince many of those still using the coke fire that much speedier and somewhat more economical results are obtained by baking the cores over a fuel oil flame. Naturally the relative economy depends to large extent on arbitrary conditions, such as the delivered price of each kind of fuel, the available storage facilities for each, and the available steam or air for atomizing. Moisture in the steam line is very easily eliminated by making the oven superheat its own steam by means of a coil of wrought iron pipe, laid on top of the arch of the fire box, through which the steam by-passes before entering the burner.

The use of a cement briquette testing machine is found most convenient by founders purchasing flour, core compounds, and binders in large quantities. This is a device which costs very little. With insignificant labor and loss of time, the proper use of such a machine will leave no foundryman in the dark as to the relative bonding strengths of various compounds and binders, each claimed to be the best.

Providing for sufficiently free shrinkage to avoid rupture is perhaps one of the chief concerns of the modern open-hearth steel founder, making large castings or those of intricate design. Enough of interest might be said upon this topic to merit its receiving exclusive treatment in a paper such as this. Location

of gate and of risers, pouring temperature, quality of facing and cores, position of flask bars, uniformity of section, nature and relative position of members of casting, run-outs, excess of phosphorus and sulphur, over-oxidation, all of these causes and many others, some not yet fully known, have bearing on this question of contraction.

Casting.

Pouring the metal into molds justly receives the closest attention. Aside from the waste and attendant unpleasantness, due to leaky stoppers, which may be the result of the ladleman's carelessness, the use of defective materials, or the melter's poor judgment, there are found at times scrap castings as a result of clean, but unskilful pouring. Preliminary to tapping the furnace, the ladle is daubed over its brick lining and dried, usually with an oil flame for about three-quarters of an hour. Then the stopper rod is adjusted, and the lever raised and lowered to see that the nozzle correctly seats the stopperhead. If the metal, on entering the ladle, is not hot enough, or if the cold additions are thrown into the ladle too soon, a skull of half-frozen metal will form around the nozzle, preventing the seating of the stopperhead and thereby a clean shut-off, until such skull has been melted and freed from the nozzle. If the metal is too hot, the nozzle is frequently first to suffer by cutting out, and this usually results in a heavy per cent. of "spills." Should the ladleman permit the stopper to float, or not pinch the stopper tight against the nozzle, a small dribble may appear, and by soon cutting the nozzle, result in a most serious leak. Care must always be exercised not to raise the stopper too high on the first mold, or to close it too soon, after being first opened.

Finishing.

Cleaning and chipping steel castings do not offer any novelties to foundry methods in other metals, other than the increased difficulty of removing the tougher metal. The use of pneumatic chipping hammers, cutting-off saws, sand blasts, tumbling barrels, and similar equipment, depends largely on the character of work in each individual shop.

The welding of minor defects in open-hearth steel castings when properly performed is attended with good results and is permitted with reasonable limitations by most of the large consumers, such as the railroads, and the United States government. Both the autogenous and the electric method have their respective adherents. My experience has been that the former is more suitable for very light sections, and the arc better for medium or heavy sections, in cast steel. In the application of either method, ample heat must be produced for satisfactory work. Good welds cannot be expected with insufficient gas or amperes of current. Preheating and afterheating the castings, if of heavy or ununiform section, tend to prevent the cooling strains from causing injury. Hammering the weld intermittently while under heat, checks the formation of slag and gives a closer union. On a tensile test, one should get an average efficiency of 60 per cent. to 65 per cent. of the ultimate strength of the natural cast steel. The elongation and reduction of area are considerably reduced. Analysis shows the metalloids to be almost entirely oxidized, leaving nearly pure iron in the weld, and thus explaining the loss in strength.

The annealing of steel castings must be very carefully done, and attended with constant reference to a reliable pyrometer, to be of the slightest value. The generally accepted correct annealing temperature is about 800° C. Should the casting be subjected to a temperature appreciably lower or higher than this figure, more damage than benefit accrues. Hence the necessity for extreme nicety of operation in annealing castings lacking uniformity of section, to avoid overheating the lighter members and underheating the heavier ones. The necessity for annealing at all should be governed largely by the composition of the steel, whose analysis may be such as to make of annealing a needless operation for ordinary work.

Inspecting.

The loss in bad castings, of course, depends to no small degree on the severity of the inspection and the class of work common to the shop. However, the ordinary open-hearth steel foundry, producing an average run of work and following a

thorough and intelligent inspection system will, if my observations count for anything, have close to 4 per cent. of scrap castings, if working molders and core makers during daylight hours only, and 6 per cent. if compelled to employ this labor on both day and night shifts. The cause for this difference is readily understood by any foundryman.

Recording Results.

The writer has found that a "follow-up" report system of each individual heat is very helpful, and submits herewith a copy of a form used for this purpose. It will be seen that some days must elapse before all of the information called for can be supplied. The plan is for the report to reach the operating head usually inside of an hour after the ladle has dumped her slag, with all data supplied by heat checker, foundry foreman, chemist and melter on the title side of the sheet, which is then filed in a convenient fashion in the operating office. From then on, the acquisition of the remaining data is gradual as the work progresses through the plant, being transferred to the reverse side of the sheet as the various reports are transmitted. There are no doubt many similar reports in use, and this one is appended for your comparison with what you may be daily referring to. I have found that such a condensed general history of each heat poured is a most helpful auxiliary to the numerous reports in greater detail.

HEAT REPORT.

....191....

To The Gen'l Supt:

Furnace No............Tapped Heat No.....................At..............M... ....Test Block

Charged Extra......................Lbs. Poured in Molds......................Lbs.... ....Pigs

... .Ingots. Last 1200 Lbs. Cast (Disregard if as much as 1 Pig or ½ Ingot is Poured):

....

Remarks:...

....................................Heat Checker.

Nature of Shut-off...

....Weight of Spills...

Temperature—of Ladle...................................of Metal...

Quietness of Metal ....

Cause for Fdy. Dept's Delay to Heat...

....

Weight of Scull..

Remarks:...

....

....Fdy. Foreman.

Results of all

C	P		C	P		C	P		C	P	

Preliminary Analyses

C	P		C	P		C	P		C	P	

.... Chemist.

Condition of Furnace after Preceding Heat (Including Bottom, Roof, Ports, Etc.).. ....

....

....

Charged at................M. by...

Oil Pressure (Lbs., Regularity and Temperature)...

....Steam Pressure (Lbs.)... .. ....

Air Pressure (Lbs. and when used)...

Quality of Scrap...

Action of Furnace..

Condition of Furnace During Heat..

Cause for Delay to Heat...

Cause for Addition of Extra Pig..

Temperature when Tapped...

Character—of Tap............................of Introduction of Final Additions........................ ....

Remarks:...

....

....Melter.

HEAT NO. ....

Final Chemical Analysis of Heat	C	P	S	Mn	Si

PHYSICAL TESTS.

Elastic Limit per sq. in ....
Tensile Strength " " ....
Ratio of Elasticity, % ....
Elongation in 2 in., % ....
Reduction of Area, % ....

PHYSICAL ANALYSIS OF METAL CHARGED.

..........Pig	..........Lbs.=	..........%	Rail	........Scrap	..........Lbs.=	..........%
.... "	.... "	..........%	Spg	.... "	.... "	..........%
.... "	.... "	..........%	....	.... "	.... "	..........%
.... "	.... "	..........%	....	.... "	.... "	..........%
.... "	.... "	..........%	Fdy	.... "	.... "	..........%
Total Pig	.... "	..........%		Total Scrap	.... "	..........%

Approx. % of all Scrap Catgs ....
Cracked Catgs ....
....
....
Hollow Catgs ....
....
Mis-run Catgs ....
....
Remarks: ....
....
....

TITANIUM FOR MALLEABLE IRON.

By C. H. Gale, Pittsburgh, Pa.

The remarkable efficiency of titanium for deoxidizing metals has led to many tests along this line. In order to learn what good might result when ferro-titanium is added to "malleable," the writer made a series of tests which he begs to contribute as part of the investigations of the American Foundrymen's Association. While the information obtained does not close the matter definitely, it is of sufficient interest to warrant presentation at this time, and may be of assistance to producers of malleable iron whose furnace practice cannot readily be brought up to the highest type.

The first series of tests were made with ferro-titanium additions to the ladle. The alloy was supposed to contain about 10 per cent. titanium; in reality, however, it ran higher, or about 17 per cent. As this condition resulted in an increased difficulty in melting the alloy, particularly where the larger quantities were used, considerably less of the alloy was actually taken up than the calculated quantities would indicate. It must further be remembered that in comparing tests with titanium in molten gray iron and malleable, that the latter, while appearing intensely hot, may in reality be of a lower temperature than an ordinary foundry melt.

In the tests three hand ladles containing about 40 pounds of iron each were taken from the very early part of a 15-ton heat made in the open-hearth furnace, the heat being the second one of that day. The first ladle was held without any titanium alloy addition. To the second ladle there was added sufficient alloy to introduce 0.125 titanium into the iron. To the third ladle double this amount was added. After stirring the second and third ladles, to get as much as possible of the alloy into solution, the contents of the three ladles were poured into three molds. It will be noted that the third ladle was the coldest of the three, 2½ per cent. of material having been added to it. The second had 1¼ per cent. added and the first ladle nothing. In conse-

quence of this it was not surprising that the heavy sprue in the case of the third mold was nearly gray in fracture, the second mottled and the first dead white. The analysis of the metal was as follows:

Silicon	0.66
Sulphur	0.046
Phosphor	0.175
Manganese	0.36
Charcoal and coke	2.66
Graphite	Trace

None of the bars to which titanium had been added showed the slightest trace of this element on analysis.

Now, while the sprues indicated the precipitation of graphite as the titanium additions rose, the bars themselves being lighter in section should not have done so for the analysis given. As a matter of fact, however, there were a few instances where they ran slightly "low" as the result of either the cooling or the titanium addition or both.

A second set of ladles treated in exactly the same manner was taken from near the end of the heat and gave the same indications.

Each mold contained two test bars, one round bar for tensile tests, varying from 0.614 to 0.637 inches in diameter for the lot cast, this dimension being at the middle of the bar, where the diameter was the smallest. With this bar was cast another one for transverse tests ½ inch by 1 inch in section and 14 inches long. All bars were carefully marked, so that they could be readily traced in the tests. The tensile tests were made on a 100,000-pound testing machine at the foundry where these tests were carried out. The transverse tests were made by Dr. R.

Moldenke on a 5000-pound transverse machine. The following are the results:

TENSILE TESTS.

First Part of Heat.

No.	Ultimate strength. Lbs. per sq. in.	Per cent. elongation in 2 inches.	Titanium added.	Remarks.
1	49,871	6.2	None.	
2	50,536	6.2	None.	
3	52,790	4.7	None.	
4	52,434	4.7	0.125	
5	47,754	3.9	0.125	
6	48,344	3.9	0.125	
7	36,257	1.5	0.250	
8	41,513	3.1	0.250	
9	43,152	3.1	0.250	
Last Part of Heat.				
10	52,649	7.8	None.	
11	49,485	7.8	None.	
12	42,971	3.1	None.	Dirt at fracture.
13	34,134	3.1	0.125	Dirt at fracture.
14	43,425	1.5	0.125	
15	52,796	2.3	0.125	
16	46,420	4.7	0.250	Flawed.
17	46,142	3.1	0.250	Flawed.
18	43,322	1.6	0.250	Flawed.

NOTE.—The regular test bar for this particular heat gave 51,819 ultimate, 7.8 per cent. elongation in 2 per cent., and 0.142 inch contraction per foot.

From the above figures, and in connection with the observations made during the testing, the following may be said:

The considerable cooling of the metal by the alloy addition in the ladle practically spoiled the test bars with high titanium additions, the metal not being able to clear itself from slag and dirt. Yet it was noticed that even with a bar flawed to one-quarter of its cross-section, an astonishingly high ultimate strength was attained. Similarly the presence of dirt and flaws affected the elongation, actually cutting this off abruptly. Hence, these figures are quite low.

Considering the above, definite conclusion cannot be drawn from the tensile test results, so far as the action of titanium on malleable is concerned. Further, a glance at the figures ob-

tained for the regular metal without titanium additions shows the improbability of serious oxidization influences that could have been corrected by the titanium additions. Trying this with cupola metal would have been another story.

TRANSVERSE TESTS.

First Part of Heat.

No.	Broke at lbs. per sq. in.	Deflection in inches.	Titanium added.	Remarks.
19	1,070	0.80	None.	
20	1,090	0.88	None.	
21	1,050	0.80	None.	
22	*1,380+	*1.80+	0.125	
23	1,270	1.62	0.125	
24	*1,370+	*1.80+	0.125	
25	1,200	1.13	0.250	Flawed.
26	1,040	0.55	0.250	Badly flawed.
27	1,050	0.47	0.250	"Low" fracture.
Last Part of Heat.				
28	1,200	1.22	None.	
29	1,260	1.30	None.	
30	1,180	1.20	None.	
31	1,260	1.40	0.125	
32	*1,320+	*1.80+	0.125	
33	1,290	1.68	0.125	
34	1,030	0.58	0.250	Badly flawed.
35	*1,310+	*1.80+	0.250	
36	1,340	1.32	0.250	Slight flaw.

The next series of tests was to observe the effects of titanium in "malleable" when added to the bath of molten metal. The alloy was added after the charge had melted down and the slag had been skimmed; that is, about 30 to 45 minutes before tapping the 10-ton afternoon heat of an open-hearth furnace. The bars cast gave the results herewith recorded.

* Beyond the range of the machine, so far as deflection was concerned. The test pieces in these cases were not broken, and might have shown some increase in the figures given for the breaking strength, had it been possible to carry the bending further on.

Flawed—has reference to sponginess, pin holes, etc., along the outer fibers only—where maximum strain was applied. All the bars had the usual sponginess of the interior to be found in malleable castings that are long and flat.

TENSILE TESTS.

No.	Date.	Ultimate strength. Lbs. per sq. in.	Per cent. elongation in 2 inches.	Titanium added.	Remarks.
37	Feb. 7	58,558	6.2	None.	First of heat.
38	Feb. 7	55,534	7.1	None.	First of heat.
39	Feb. 7	55,884	4.7	None.	Last of heat.
*40	Feb. 7	43,666	3.9	None.	Last of heat.
41	Feb. 8	54,761	6.2	None.	First of heat.
42	Feb. 8	44,841	3.1	None.	First of heat.
43	Feb. 8	53,835	6.2	None.	Last of heat.
44	Feb. 8	54,135	4.7	None.	Last of heat.
45	Feb. 9	58,160	9.3	None.	First of heat.
46	Feb. 9	54,233	6.2	None.	First of heat.
47	Feb. 9	57,755	10.9	None.	Last of heat.
48	Feb. 9	48,272	3.1	None.	Last of heat.
49	Feb. 10	52,333	4.7	0.03	First of heat.
50	Feb. 10	57,518	7.8	0.03	First of heat.
51	Feb. 10	58,479	4.7	0.03	Last of heat.
52	Feb. 10	55,802	2.3	0.03	Last of heat.
53	Feb. 12	56,717	6.2	0.03	First of heat.
54	Feb. 12	59,141	4.7	0.03	First of heat.
55	Feb. 12	56,468	3.9	0.03	Last of heat.
56	Feb. 12	50,801	7.8	0.03	Last of heat.
57	Feb. 14	50,855	10.9	0.03	First of heat.
58	Feb. 14	52,574	9.3	0.03	First of heat.
59	Feb. 14	53,509	3.9	0.03	Last of heat.
60	Feb. 14	56,906	7.8	0.03	Last of heat.
61	Feb. 15	48,770	6.2	0.06	First of heat.
62	Feb. 15	53,866	2.3	0.06	First of heat.
63	Feb. 15	49,679	4.7	0.06	Last of heat.
64	Feb. 15	49,377	3.9	0.06	Last of heat.
*65	Feb. 16	42,456	1.5	0.06	First of heat.
66	Feb. 16	50,133	4.7	0.06	First of heat.
67	Feb. 16	59,933	4.7	0.06	Last of heat.
68	Feb. 16	50,797	6.2	0.06	Last of heat.
69	Feb. 17	63,443	7.8	0.06	First of heat.
70	Feb. 17	50,352	3.1	0.06	First of heat.
71	Feb. 17	57,397	9.3	0.06	Last of heat.
*72	Feb. 17	45,379	1.5	0.06	Last of heat.

* Flawed.

TRANSVERSE TESTS.

No.	Date.	Broke at lbs. per sq. in.	Deflection in inches.	Titanium added.	Remarks.
73	Feb. 7	1,175	1.62	None.	First of heat.
74	Feb. 7	1,150	1.58	None.	First of heat.
75	Feb. 7	1,050	1.51	None.	Last of heat.
76	Feb. 7	1,050	1.42	None.	Last of heat.
77	Feb. 8	1,020	1.58	None.	First of heat.
78	Feb. 8	1,050	.89	None.	First of heat.
79	Feb. 8	1,005	1.32	None.	Last of heat.
80	Feb. 8	925	1.03	None.	Last of heat.
81	Feb. 9	1,070	1.10	None.	First of heat.
82	Feb. 9	1,275	1.32	None.	First of heat.
83	Feb. 9	1,030	1.30	None.	Last of heat.
84	Feb. 9	1,050	1.30	None.	Last of heat.
85	Feb. 10	1,100	1.61	0.03	First of heat.
86	Feb. 10	1,070	1.07	0.03	First of heat.
87	Feb. 10	1,170	1.32	0.03	Last of heat.
88	Feb. 10	1,130	1.53	0.03	Last of heat.
89	Feb. 12	1,110	1.15	0.03	First of heat.
90	Feb. 12	1,330	1.75	0.03	First of heat.
*91	Feb. 12	1,275+	1.80+	0.03	Last of heat.
92	Feb. 12	1,460	1.15	0.03	Last of heat.
93	Feb. 14	1,210	1.30	0.03	First of heat.
94	Feb. 14	1,120	1.32	0.03	First of heat.
95	Feb. 14	1,130	.82	0.03	Last of heat.
96	Feb. 14	1,290	1.57	0.03	Last of heat.
97	Feb. 15	1,180	1.70	0.06	First of heat.
98	Feb. 15	1,160	1.80	0.06	First of heat.
99	Feb. 15	1,220	1.20	0.06	Last of heat.
100	Feb. 15	1,105	1.59	0.06	Last of heat.
101	Feb. 16	1,240	1.60	0.06	First of heat.
*102	Feb. 16	1,200+	1.80+	0.06	First of heat.
103	Feb. 16	1,190	1.17	0.06	Last of heat.
104	Feb. 16	1,170	1.35	0.06	Last of heat.
*105	Feb. 17	1,180+	1.80+	0.06	First of heat.
106	Feb. 17	1,130	1.15	0.06	First of heat.
107	Feb. 17	1,090	1.32	0.06	Last of heat.
*108	Feb. 17	1,240+	1.80+	0.06	Last of heat.

From the tables it will be noted that the percentage of titanium added to this second series of tests was much less than in the first. Here, also, no titanium remained in the metal of the heat.

Both series plainly show improvement in the metal as indicated by the transverse test. Unquestionably, the undue cooling of the metal by the alloy additions in the ladle militated against soundness on the part of the bars, particularly for the tensile test, the bars being round, and hence the results obtained should not be taken too seriously. In the case of the transverse bars, however, they are somewhat different, for in the actual test the strain is principally on the outer fiber of a flat bar, and this portion of the bar is usually pretty sound. The excellent bend-

* Beyond range of machine for deflection. Test bars not broken and might have shown increase in breaking strength had it been possible to carry on the test further.

ing results obtained in spite of the interior shrinkage, due to cold metal in the first series of bars, gave a more reliable clue to what was going on.

The one interesting point lies in the action on the heavier section, where graphite was thrown out. Undoubtedly, the cooling action had much to do with this.

Titanium, however, as well as aluminum, when used in comparatively large quantities for purifying effects, has the effect of allowing graphite to separate out easier and doubtless—for the titanium as well as aluminum disappears completely in the dioxidation—so frees the metal treated from influences retarding the separating out of graphite, that a purified low silicon iron behaves just as the ordinary metal with higher silicon would in this regard. Here again we see the difference between charcoal and coke iron malleable practice. The silicon in charcoal iron charges for malleable ought to be lower than for coke irons, otherwise for the same section the metal would come out "low" in fracture.

It would seem that the use of titanium in malleable would be particularly advantageous for the heavier classes of work in allowing the silicon to run much lower, and, in doing this safely, give good soft, strong castings.

ANALYSES OF HEATS.

Date.	Furnace No.	Heat No.	Time.	Si.	S.	P.	Mn.	C. C.	G. C.
Feb. 7, 1911......	5	778	P. M.	.66	.043	.200	.24	2.56	None.
Feb. 8, 1911......	5	779	P. M.	.57	.038	.191	.29	2.72	None.
Feb. 9, 1911......	5	781	P. M.	.68	.043	.195	.29	2.72	None.
Feb. 10, 1911.....	5	783	P. M.	.50	.035	.202	.26	2.54	None.
Feb. 12, 1911.....	5	785	P. M.	.66	.040	.198	.28	2.72	None.
Feb. 14, 1911.....	5	787	P. M.	.54	.042	.211	.26	2.64	None.
Feb. 15, 1911.....	5	789	P. M.	.56	.037	.189	.23	2.70	None.
Feb. 16, 1911.....	5	791	P. M.	.71	.040	.193	.26	2.56	None.
Feb. 17, 1911.....	5	793	P. M.	.54	.036	.202	.30	2.76	None.

The records given in this paper are presented in the hope that further research may be undertaken along these lines, for the correction, or, still better, prevention, of oxidation of "malleable" in the melting is of the highest importance, long-drawn-out heats being the cause of many troubles from weak iron. Where it is impossible to obtain quick heats for some reason or other—until the cause is removed—there titanium would seem to offer a substantial advantage.

THE CONTROL OF INDUSTRIAL FIRE INSURANCE COST.

By S. G. Walker, Providence, R. I.

Insurance is a contract, commonly termed a policy, whereby one party, the underwriter, for an agreed consideration of premium proportional to the risk involved, undertakes to compensate another party, the assured, for loss on a specified thing from specified causes. An insurance company is therefore an accumulation of capital for the purpose of meeting such possible or probable events as experience has proven may result detrimentally to an individual or community, either as affecting life, health, comfort, or the more tangible and measurable features of welfare involving property values. The protection afforded may aim to neutralize either the results of nature's well defined laws, operating in an entirely usual way, or the uncompromising rebellion against abuse of an element designed to serve man's comfort and welfare.

Fire, one of man's best servants, and almost become a necessity to his existence, has shown itself the veriest tyrant in its levy on life and property when vigilance is abated or restraint slackened. The main purpose of fire insurance is the distribution of this class of losses over the community in such a manner as to soften the blow to the individual, but it further serves to level the uncertainties, thus constituting an important bulwark of commercial confidence, the very foundation of our modern credit system, and one of the most powerful elements in the world's past progress, as it is bound to be in future advancement. It has been characterized as a gamble with the forces of nature, but it is hardly that, as gambling involves the creation of a risk, while insurance is rather the transfer of an existing hazard.

The simplest method of relieving misfortune is by voluntary contributions following the event, which, however, is not really insurance according to the commonly accepted meaning, but would rather come under the head of benevolence or philan-

thropy. When those exposed to a possible misfortune agree between themselves in advance to contribute for the relief of the sufferer if it occurs, the simplest form of true insurance is involved, as exemplified in assessment societies and town or county co-operative societies. When such an association actually collects a premium in advance, it constitutes a mutual company, the rate of premium being based upon a general average, which in turn can only be determined from experience, and the number of risks involved must, for success, be sufficient to establish average conditions of loss; that is, to spread a possible heavy loss on any one risk over a considerable period of time as regards its effect on the cost to others. Mutual companies further commonly reserve the right to assess their members in event of a serious depletion of resources by successive large losses, and it is usual to return all or a part of what remains of the premium after disbursements have been made. A stock company is evolved by the entrance of an outside party to collect the premium and guarantee payment of losses, relieving the assured of liability to future direct assessments, although they may be imposed indirectly through the general raising of rates which inevitably follows the occurrence of a large conflagration. Such companies are, of course, organized primarily for the purpose of paying dividends to stockholders and therefore chiefly interested in collecting sufficient premiums to make this possible.

It is self-evident that whatever the form of insurance the effect is essentially mutual, in that the community at large foots the bills for whatever losses may occur, and the sort of vague idea somewhat prevalent that when a company pays a loss the incident is closed as far as the rest of the community is concerned, is, of course, a fallacy, the previous collections being often lost sight of. The mass of the assured stand behind a stock company as truly as if they were united to form a mutual company.

A glance at the history of fire insurance indicates that actual development has pretty closely followed the theoretical. The principle of sharing each other's misfortunes, in one way or another, has doubtless been co-existent with the human race, but fire insurance, as known to-day, came into existence fol-

lowing the great fire of London in 1666,—relatively, and in effect, the greatest which ever occurred, burning four days and nights, involving an area of 436 acres, 85 per cent. of the buildings in the city, and a property loss calculated at about $300,000,000, present-day values. The early companies were co-operative in nature and the first mutual company, in which the members shared directly in the losses, was organized in 1683. The first modern stock company, organized in 1720, still exists, and the freedom from liability, beyond the payment of a stated premium, has been such an attractive feature that this form of insurance has taken precedence to the extent that to-day 90 per cent. of the general business is said to be handled under this plan. In many of the early companies marine insurance was the principal feature, with fire insurance rather in the nature of a side line, for the perils of the deep were more constantly and impressively before the community and concentrations of value were not sufficient to make protection against fire as important as it later became.

America quite naturally copied England in the development and character of her early insurance companies, and in Philadelphia two mutual companies, started in 1730 and 1784 respectively, are still doing business. One of the earliest mutual companies in New York dated from 1787, but in 1846 was changed to a stock company. The oldest New York stock company was organized in 1806. Up to the close of the eighteenth century there were about ten mutual companies and four stock companies in this country and as late as towards the middle of the nineteenth century some companies continued to pay losses by subscription or contribution, but this type of insurance has now practically disappeared. Previous to the New York fire in 1835, involving $15,000,000 property loss, the companies were largely local and therefore not on a broad enough base to weather such a blow, thus many were swept out of existence by this fire. The forming of large numbers and varieties of mutual companies followed, but this system as applied to a general business, has not been broadly successful and but two forms have persisted,—the local or county mutuals, in which the members of a small community share losses, while light expenses, scattered risks and a common acquaintance,

tending to eliminate or reduce the moral hazard, combine for favorable results,—and the so-called "Factory Mutuals" based on a study of hazards, careful inspections, and physical improvement of the properties involved.

The Manufacturers' Mutual Fire Insurance Company of Providence, R. I., organized in 1835, was the originator of the latter type of company, and its inception was due to the fact that certain manufacturers were unable to secure concessions in rates, to which they considered themselves entitled on account of improved construction and superior care of their properties as compared with average conditions in that class of risk. They accordingly determined to associate themselves for the purpose of carrying their own insurance, and from this nucleus a system has grown involving 2,600 high grade manufacturing properties aggregating a value of over $2,250,000,000. There are now nineteen companies operated on this basis, associated for engineering, laboratory, and inspection purposes, and known as the "Senior Group," while another group, called "Juniors," write an aggregate of approximately $250,000,000, making a total, in round figures, of $2,500,000,000 for the entire mutual system. References in this paper to mutual companies will bear on the senior group and particularly the six companies now combined and operated under one management in the manufacturers' office.

The cost of insurance may be divided for purposes of analysis into loss ratio, expense ratio, and profit. The loss ratio consists of that portion of the premiums devoted to payment for property damaged or destroyed by fire, including an indeterminate factor due to fraud or carelessness, introduced by the very existence of insurance and styled vaguely "moral hazard." It evidently comprises all the uncertainties of the business and is therefore the basic reason for insurance, but it is also, more than any other feature of cost, in the control of the assured and may logically occupy a considerable part of our examination into the possibilities of reduction, as anything which lessens the degree of uncertainty will inevitably lower the cost.

The total fire loss in the United States approaches $250,000,000 a year, while the maintenance of public fire departments to prevent still heavier loss involves about an equal

outlay. These are pretty large figures for the mind to grasp, but reduced to simpler terms, mean a tax on the entire community of about $1,000 per minute; not a periodical matter, such as the expense of carrying on a war or relieving the effect of any temporary calamity, but a continuous, depressing drain upon our resources, such as would not be countenanced by a less prodigal nation and could not by a less prosperous.

The cost of insurance with the stock companies may be roughly apportioned as follows:—

		Per Cent, of Premium.
Losses		55
Expense ratio—		
Commissions	15	
Salaries and special agents	5	
Maintenance of Home Office	15	
Taxes	3	
	—	38
Profits		7
		100

It thus appears that losses constitute the largest item of cost to the companies as well, and would on this account also be the logical point of attack in attempting a reduction. It was formerly the apparent province of stock companies to take losses as they were found and assess them on the community, rather than to exert themselves for a reduction by urging better forms of construction, adequate protective appliances, and fire-preventing devices. This attitude, however, has been and is, with increasing inertia, undergoing a change, so that to-day the best companies are paying a good deal of attention to conservation of properties.

With the mutual companies the loss feature is more directly in evidence, as their plan, having no stockholders, is to charge in advance a premium rate amply in excess of anticipated losses and operating expenses, thus providing funds for safe and comfortable operation, and at the end of the policy period, after deducting these items and crediting the interest income, the balance is returned to the assured, except such portion as the directors deem wise to contribute towards a surplus, in the form

of a rebate or dividend. In the manufacturers' office the average premium rate last year was 76 cents per $100, while the dividends and net costs for several years past have been as follows:—

	Average Dividend. Per Cent.	Net Cost. Cents.
Ten years	92.5	5.7
Five years	93.3	5.09
Three years	94	4.56

The distribution of cost to premium income for last year was as follows:

	Per Cent.
Losses (fire and sprinkler leakage)	2.8
Expense ratio	6.4
Total	9.2
Deduct interest income	4.8
Net cost	4.4
Premium not absorbed	95.6
Dividend paid	94
Contribution to surplus	1.6

The premium rate in these companies is roughly the same as the average with the stock companies and it thus appears that their losses are about one-twentieth of the average with stock companies, while their expenses are about one-sixth.

Experience with losses so directly affecting costs quickly called attention to the desirability of devising protective apparatus and other means for reducing fire loss, and how vital a feature this was considered is best brought out by quoting Article V, Sec. 1, of the By-Laws, which reads as follows:

> The objects of this company are: First, the prevention of fire loss to its members through promotion of knowledge of safeguards, inspection and warning against dangerous conditions; second, the provision of insurance to its members at cost and the equitable distribution among its members of such fire losses as they may incur; and for this purpose to establish a reserve, so that losses due to unusual conflagrations may be more widely distributed and greater security provided for the payment of such losses. The business of the company shall be conducted on the co-operative or mutual plan, without purpose of profit, according to the methods prescribed below.

Thus the conservation of property is evidently the prime object, while low cost insurance is rather in the nature of a result. How well they have succeeded in the control of losses is evident from the present low loss ratio as compared with that in stock companies, bearing in mind that factory insurance as a class was considered most undesirable in the early days, whereas it now enjoys the reverse reputation when protected along lines chiefly developed and perfected by the mutual companies. The present rate of dividends may be considered a rough measure of the reduction in loss which has been accomplished and it will be interesting to examine into the reasons underlying this achievement.

The American people are proverbially the most careless on earth as regards conservation of resources. We enjoy the distinction of having a fire loss per capita of eight to ten times the average in European cities, and although this may at first glance be accounted for by cheap lumber available for frame construction, statistics show that the losses on frame buildings are two-thirds and on brick buildings one-third of the total, so the elimination of this feature would only reduce our loss one-third. It is, of course, true that a large proportion of our brick buildings have frame floors and roofs, whereas in European cities almost no wood is used in the construction of buildings. That our relatively high fire loss is not due wholly to constructive conditions is made pretty evident by the fact that with us the number of fires in proportion to population is about five times as great as in European countries. Here again we lead the world, but with little cause for pride. It is calculated that reducing our conditions to a parallel with those in foreign countries would eliminate four-fifths of our fire losses and a like percentage of the cost of maintenance of fire departments.

It is estimated that 60 per cent. of fires start from careless or preventable causes, and although it is clearly impossible to wholly eliminate these, good management goes far towards effecting a reduction, and this was made the first point of attack with the mutual companies. In the early days, with no protection which would be recognized as such to-day, it may be said to have been a matter of good luck reinforced by good management, or perhaps later the reverse, that kept factory properties from burning.

The success of the mutuals has been as much due to the efficient inspection of their risks as to any other one cause, for in the long run this was bound to reduce losses below what the stock companies experienced, operating with no concerted attempt at supervision of hazards. This vigilance has not been in the least relaxed in the mutual system since the general introduction of modern fire fighting apparatus, for if a fire can be prevented it does not need to be extinguished and even a small loss is avoided.

The inspection department of the mutual system to-day employs twenty-three regular men who normally follow in succession through the risks insured, unless the sequence is disarranged by sickness or other cause. Four inspections a year are made of each property insured and it takes a man nearly six years to complete the rounds of the membership. It might be more economical to localize this work by placing a man in charge of a certain district and permitting him to repeatedly visit the same risks, but the present plan is preferable, as tending to eliminate the personal equation and secure composite results, thus equalizing efficiency to all members.

These men are chosen for their various qualifications, educational and practical, which peculiarly fit them for the work in hand and there can be no question but that the advice of such experts, bringing to bear a voluminous knowledge of fires, their origin and extinguishment, is of inestimable value to any one interested in reducing his loss. The inspections are most thorough, investigating and reporting upon, in minutest detail, anything which has a bearing on fire hazard. Heading the list of features is that of order and neatness, or housekeeping, and it frequently takes several years to get a new member up to the mutual standards in this respect, but right here is the feature of carelessness sought out and corrected. All the physical characteristics of a property, affecting hazards or the extent of a probable fire loss, are examined into and noted, covering such features as construction, exposure, occupancy, heating, lighting, protection and management, which are rated according to the judgment of the inspector. Previous reports are not accessible to him, but his is put alongside those of his predecessors and successors in the offices, and a group of these expert opinions gives the officers of the companies a pretty clear idea of conditions at a property. It will be

apparent that no superficial examination of a risk would enable a man to form his judgments, but he must see every part of every room and examine all apparatus. Once a year the supplies to the protective equipment are subject to actual test under fire conditions of draft and their efficiency proven beyond question.

The inspection department has also a corps of special inspectors, who are expert in various lines and thus in a position to advise on any engineering features having a bearing on fire loss. It also handles adjustments, appraisals, and provides an elaborate descriptive plan of every risk for circulation to the companies and to the assured, all of which service is included in the cost of insurance, and many who have had experience have expressed the opinion that these matters alone are worth the entire cost to the assured. As a matter of fact the maintenance of this department represents about as much in outlay as the average losses amount to, under present-day conditions of protection and, while the results cannot be reduced to dollars and cents, there is no question but that the fires prevented each year pay for the cost of maintenance several times over.

Perhaps the feature next in importance, as bearing on fire loss, is the construction and this has been the subject of careful study by the mutual companies, with the result that a type called "slow-burning" has been evolved and advocated as superior to all others in its fire-resisting qualities, with the exception of some non-combustible types. The aim in slow-burning or mill construction is to concentrate the timber in floors and roofs into large sections, offering smooth surfaces and few corners for a fire to attack. The old style of joisted type bears about the relation to this, in rapidity of combustion, as kindling wood does to cord wood. A few years ago two fires were experienced, at about the same time and under similar conditions of protection, and the joisted roof fell in on the fire in about twenty minutes, while the slow-burning roof stood for two and one-half hours. The tendency for rapid spread of fire vertically makes it important that openings through floors be avoided. Stairs and elevators are best provided for in brick towers with doorways protected by fire doors, and such stairways also serve the very desirable purpose of efficient fire escapes, but if permitted inside, as is sometimes the case in low buildings, the floor openings should be protected with

automatic hatches, or, in the case of stairways, enclosed with substantial sheathing or cement plaster on wire lath, a heavy door being provided at each floor. Belt openings may be protected with metal hoods or important belt-ways enclosed with cement plaster on expanded metal. If a building is equipped with automatic sprinklers these openings become still more detrimental, as the passage of heat to floors above, even in advance of the fire, will set off sprinklers and increase the water damage, besides robbing the system of water pressure where needed most at the seat of the fire. Without vertical openings it is highly improbable that a fire will spread between stories in a slow-burning building.

Walls should preferably be of brick or other refractory material, and fire cut-offs, in the form of blank walls with fire doors and shutters at the necessary openings, are advisable to separate large values, special hazards, or important departments. Stone is unreliable as a fire-resisting material and its use should be avoided when conditions will permit. Frame constructed walls are hardly suitable for important manufacturing properties and the saving which they effect is not as great as is commonly supposed, ranging from 5 per cent. for substantially built structures to 30 per cent. for small high buildings, 15 per cent. being perhaps a fair average. The only saving which frame construction affords is in the lighter foundations and in the actual outside surfaces of a building. Necessary openings in walls exposed to neighboring properties may be protected by wired glass in metal frames or standard tinned shutters, bearing in mind that nothing will stand the attack of fire as well as a blank brick wall, and this therefore should be approached in proportion as the exposure hazard is of serious importance.

Reinforced concrete and other types of non-combustible construction have been coming into more and more general use as the price of lumber has advanced and, with heavy floor loads demanding large sections for timber-construction, concrete approaches slow-burning in cost. Under favorable conditions and with expert workmen the difference will now run from 5 per cent. to 10 per cent. The advantages claimed for concrete are greater rigidity, less depreciation and, of course, incombustibility, while slow-burning has the advantage of slightly lower cost and lends itself more readily to changes or repairs when damaged.

Each type has its uses and neither may be said to be generally preferable. Iron and steel are absolutely unreliable when subject to the action of fire and if used at all should be thoroughly protected with an insulating covering.

No definite rules for general application can be laid down for construction, but each case must be the subject of special study and the details determined according to conditions of use, etc. The value of construction as reducing loss on stock is much overestimated, and the history of fires in fire-proof buildings without sprinkler protection shows that, with a fire well started, the destruction of the contents in that particular compartment is imminent. So-called "fire-proof" construction is highly effective in preventing the spread of fire between floors and in reducing the exposure hazard to a minimum, but should not be depended upon for anything further.

The occupancy of a property has great bearing on its desirability as a mutual risk, and not only must the operations and materials employed be in themselves reasonably safe, but the arrangement of processes must be such as to isolate specially hazardous features where they will not impose their dangers upon large values or important departments. The mutual companies insure a large variety of industrial establishments, including cotton, woolen, linen, silk, pulp and paper, machine shops and foundries, metal workers of various kinds, shoe shops, tanneries, food products, rubber clothing, lithographing and printing, bleaching, dyeing and finishing, jewelry and silverware, soap, optical instruments, and chemicals. The inherent hazards in each class of manufacture are carefully scrutinized and the danger of fire minimized.

Some of the causes of fire in foundries are sparks from cupolas, flues, hammers, or smouldering in flasks; overheated flues, core ovens, japan ovens; fuel oil systems, through the breaking of pipes or explosions in furnaces; hot castings, in contact with flasks or patterns; ignition of woodwork not properly insulated from steam pipes, cupolas, flues, etc.; the dipping of materials in volatile compounds; smoking and careless use of matches among employees; defective electric wiring; friction of journals or bearings; spontaneous combustion from oil-soaked materials, and a considerable proportion, possibly 10

to 15 per cent., unknown. The precautions and correctives are usually obvious under careful study and the application of common sense.

Most authorities agree that from 25 to 30 per cent. of fires spread beyond the building in which they originate, and the matter of exposure is therefore a considerable element in determining the character of a fire risk. Some foreign countries make a party responsible for the destruction of a neighbor's property, either through his own fault or by a fire originating on his premises, the burden of proof being on the owner, but in our free country a man must suffer from the mistakes of his neighbors without redress. A conflagration is to fire insurance what an epidemic is to life insurance, although modern fire fighting apparatus has been less able to control the former than has advanced medical science the latter.

In the years 1901-1905 inclusive there were twenty-three conflagrations in the United States involving a loss of $1,000,000 or more. In the years 1905-1910 inclusive there were forty-one of like magnitude and the total of these losses for the ten years was $527,000,000, the average per conflagration being $82,000,000, but excluding the two largest, Baltimore and San Francisco, reduces this average to about $2,000,000. The damage involved in the San Francisco fire in three days was more than all the other large conflagrations for forty years put together. In five of the largest conflagrations it developed that only 54 per cent. of the property values were covered by insurance; thus, aside from the fact that many companies are put out of business by such an occurrence, a large number of private individuals are practically ruined. If Manhattan Island were subjected to a conflagration involving a like area to that swept in San Francisco, it is hardly going too far to say that no stock company would be left in the business, while the effect on the mutuals would be practically negligible.

The mutual companies aim to avoid congested portions of cities where the conflagration hazard is imminent, but whenever dangerous neighbors are present adopt protective measures against them, and as a result have never lost a dollar in any of the large conflagrations occurring in this country. On the other hand, a sound stock company must provide for occasional con-

flagration losses by setting aside a liberal percentage of the premium income as a fund for this purpose, and even then every exceptional disaster is followed by numerous failures. In the last fifty years it is estimated that 30 to 40 per cent. of the premiums in large cities have been necessary to provide for conflagration losses alone.

The intangible but quite commonly influencing factor of moral hazard is due either to a desire to destroy or lack of a strong desire to preserve property on the part of the owner, and either one makes for laxity in its care and protection to the detriment of the insurance companies. Ill-will is another potent moral element. With the mutual companies, handling only high grade properties representing prominent combinations of industrial capital, this is not much in evidence, for a concern disposed to build, protect, and care for its plant along mutual lines certainly has no wish for its destruction, such a property being of more value standing than burned, and there has been no instance of proven incendiarism in the mutual system. Its general effect, however, is to materially increase the fire waste throughout the country and it is responsible for a considerable percentage of the stock companies' basis rate or irreducible minimum.

Although it is evident that fire prevention is a sufficiently laudable aim to command the most generous expenditure of effort, we must still face the unfortunate fact that occasionally vigilance will be set at naught and fires will start, with combustibles present in either buildings or contents. It early became evident that under the mutual system it was sound business policy to expend money lavishly for protecting properties rather than to pay large losses otherwise periodically inevitable, and they accordingly brought to bear the skill and inventive genius of expert mechanics and engineers to devise and perfect adequate apparatus for the purpose. Early efforts were directed to the development of systems whereby powerful hose streams from city supplies or private pumps might be concentrated at important points by means of hose attached to hydrants or inside standpipes. The value of inside protection was also made evident and the successive steps, from the crude perforated pipe system by which a room might be flooded when the controlling valve was opened, to the modern automatic sprinkler system, form one of the most

interesting examples of the ultimate triumph of persistent effort. From experimental sprinkler installations in the most hazardous departments of a few factories, their efficiency, even in the then crude form, was so evident that the mutual companies first advised, then urged, then required their members to install them.

The transition from no sprinklers to the present-day condition of practically complete protection could not, of course, be accomplished in a short time, and as a matter of fact has covered a period of about forty years. As recently as fifteen years ago it was thought logical to exercise some judgment as to where they were necessary, but a few fires in places deemed immune demonstrated the fact that it is cheaper in the long run to buy protective apparatus than to pay for factories, or parts of factories, destroyed by fires starting unexpectedly and from unsuspected causes, and the present practice is to protect every locality where combustibles are involved, either in buildings or contents. Progressive introduction of these devices has not only been attended by an increased annual dividend but the rate of dividend has been steadied and to-day is not subject to the wide fluctuations formerly in evidence, showing conclusively the elimination of a large percentage of the uncertainties. It is calculated from experience that automatic sprinklers will eliminate over 90 per cent. of the fire losses in a given factory during a period of years of sufficient length to establish average conditions. The combined annual fire and sprinkler loss to the mutual companies is now only about 30 cents per $1,000 insurance, on which basis the losses in a given factory would equal the value of the plant, under average conditions, in about three thousand years.

The manufacturing world is so familiar with this subject that it may seem like "carrying coals to Newcastle" to go further into it at this time, but the importance of spreading knowledge so vital to the economic welfare of our country leads me to proceed, in the hope that a few may be reached who are behind the procession in this respect. An installation consists of sprinkler heads so designed as to divide the issuing water into spray and spaced from 6 to 10 feet apart, either in a rectangular or staggered arrangement, as constructive details demand, the supply of water being furnished by a system of piping with sizes varying from ¾ inch for a single head to 6 inches for 200 heads, according to

a gradation determined by actual tests on flow of water and determination of friction losses in experimental systems constructed for the purpose. This piping is suspended from the ceiling of a room by means of substantial hangers, the heads usually being above the pipes, and the latter graded so as to drain to the main feed or riser, to provide for emptying the system in case of accident or necessary repairs. The splash plates are from 3 inches to 10 inches (preferably 4 inches to 6 inches) below the surface to be protected, so with the head in its vertical position the water is first thrown upwards and after sweeping the ceiling falls on the contents below, in quantity, when good pressure is available, equal to about ten times the heaviest shower of rain. Slow-burning construction evidently presents ideal conditions for extinguishment of fires, the smooth clean surfaces offering a minimum interference with distribution, and it also lends itself to the most economical installation, as the widest spacing permitted by the schedules may be used.

The normal temperature at which heads open is from 155 to 165 degrees, but for locations where unusually high temperatures prevail special heads are provided with melting points approximating 212 or 360 degrees, as the case demands, the usual practice being to provide a melting point about 50 degrees above the maximum temperature of the room. Such sensitiveness is bound to respond promptly to a call for action, and, on the principle that a cupful of water applied early enough will put out any fire ever started, this system will use less in putting out a given fire, once it is beyond the control of hand appliances, than any other type of apparatus. Innumerable fires have been handled by a single head and frequently the first warning that there has been trouble is the evidence of running water.

The adequacy of sprinklers, ready to operate without dependence upon human agency or presence of mind, wherever needed and whenever called for, persistently doing their work amid smoke, heat, and flame at the seat of the fire where no fireman could live, leaves apparently little to be perfected in the theory of efficient protection for inside property. Statistics for several thousand fires show 70 per cent. extinguished by sprinklers alone, over 80 per cent. of those extinguished using less than 12 heads, while only in 5 per cent. of the cases were they useless,

and one-half of these failures, or 2½ per cent. of the total, were due to closed valves or lack of protection in the location where a fire started. Thus, complete failure of the apparatus was evident in only 2½ per cent. of these fires and undoubtedly with equipments installed under modern conditions of perfection in the devices this would be still further reduced. The fact should not be lost sight of that they are, so to speak, only the first line of battle and their failure does not mean abandonment of hope, but the apparatus for handling fire streams, either from private sources or a public department, which is always available at a well equipped property, renders conditions even then rather more favorable, due to perfected devices, than would have been the case before sprinklers were in general use. In the face of such effective equipment the chance of small fires becoming large ones is reduced to a minimum, and, after fire prevention, this has most important bearing on the reduction of loss.

No more than very general rules can be laid down as to methods of installation, for each case should be made the subject of such special study by experts as its importance commands. It is customary in properties involving considerable values to provide two absolutely independent sources of water supply, which may be any of the following combinations: Two separate public water systems; public water system and a fire pump; public water system and elevated tank; or an elevated tank and fire pump. In case of a particularly large concentration of values it is common to increase the number of available supplies as conditions seem to demand. The primary supply is preferable from a high pressure source, such as the public water system, or tank or reservoir at a high elevation above the yard, but the secondary supply is governed largely by conditions of economy and the needs of the case. It is a rule that where outside exposure is at all serious a fire pump is desirable as one of the supplies, thus providing adequate private resources for defence against the neighborhood in the event of demoralization of the public fire department, which is almost a foregone conclusion under conflagration conditions.

In such portions of a plant as would involve danger of freezing a device, called an air valve, is inserted in the main feed. This is essentially a differential valve, whereby a moderate air

pressure excludes heavier water pressure, and upon release of the former the valve is tripped, admitting the water through a full section opening. An automatic alarm feature is added, to give warning when this condition occurs from any cause. There is also an automatic alarm device provided for attachment to a wet system and actuated by the flow of water due to fire or accident to the system.

To provide for suitable distribution of the supplies, a yard pipe system is designed according to controlling circumstances, the supplies connected to it, and sufficient hydrants installed, with the necessary equipment of hose, nozzles, etc., to secure adequate hose streams in case of extreme necessity. The several sections of the sprinkler system are commonly supplied by connections from this yard system and controlled by means of outside valves located as far as feasible from the building, controlled, so as to be most accessible in event of fire. This outside control has two distinct advantages: *First,* if a building by any chance is destroyed its valve may be closed, thus preventing waste of water and reduction of pressure from broken piping, and the rest of the system will then be intact for the protection of the remaining property. *Second,* if it is necessary to shut off a system for repairs the valve will be accessible for opening if a fire starts while these conditions exist. With a properly installed system the chief care on the part of the assured is to be certain that the valves are open and the supplies operative.

The cost of a sprinkler equipment depends so much upon local conditions governing the supplies, material, labor, competition, etc., that none but very general figures can be given, but the normal range is from 6 to 10 cents per square foot of floor area protected, and such an equipment will commonly add about that percentage to the cost of a plant. The inside work alone, without the supplies and yard pipe, will usually cost about as much per square foot as would the laying of a 1-inch floor. When it is considered that this slight additional outlay will make a property fire-proof, both as to structure and contents, the marvel is that any one hesitates to provide it where a concentration of values exists. Not alone is there the consideration of property conservation, but it is quite commonly a first-class investment through the saving to be effected in cost of insurance. It is not

uncommon for the mutual companies to show a saving of 90 per cent. as compared with the former cost for an unprotected property. The stock companies usually will make concessions in rate of about 75 to 80 per cent., particularly where the competition is active. An equipment which will pay for itself in two to five years, returning 20 to 50 per cent. on the investment, should from this consideration alone be an attractive proposition for a manufacturer to entertain. Some of the sprinkler companies have affiliations whereby they install equipments and take their pay through the saving to be effected in cost of insurance; that is, the owner goes on paying his late rate and at the end of a stipulated number of years the system is his without any additional expense.

Further interior protection is afforded by small hose, fire pails, sand pails for hazardous liquids, and chemical extinguishers, but these are really intended for handling fires before they have reached the point where sufficient heat has developed to open sprinklers.

Outside protection is essential in the way of powerful hose streams to handle outbuildings, lumber piles, cars on sidings, etc., and these become a mighty asset when there is an exposure of importance as was well brought out in the Paterson conflagration, where a line of mutual risks with their hose streams from private fire pumps checked the advance of the fire without a dollar's loss to themselves. Outside sprinklers are sometimes used as protection at mildly exposed window openings. These are open heads to which water is admitted by the opening of a valve, with the result of interposing a water curtain, but too much dependence should not be put upon them on account of the non-automatic feature and the fact that they are unable to cope efficiently with an exposure fire of serious proportions.

That independent self-protection is the only hope for large reduction in fire losses, where heavy concentrations of values exist, as in our cities, is pretty evident by the fact that improvement in our fire apparatus for use by public departments has not been able to stem the tide of our steadily increasing loss in cities. Compare the hand engine of fifty years ago, its feeble ½-inch stream pattering impotently against the third story windows, with the modern powerful engine, several of which Siamesed can throw

a solid 2-inch stream crashing through most any obstruction to the heart of the fire; or the modern fire boat, combining its power into a single 5-inch stream before which solid masonry walls totter and fall; or the high pressure systems recently installed in some of our large cities, with millions of gallons of water per hour at the will of the fire chief; and then think of our loss increasing 134 per cent. in thirty years, while the population increase has been only 73 per cent. Little dependence is placed on public fire departments by the mutual companies, but improved properties are so equipped as to be able to stand on their own resources independently of outside aid.

In view of the recent appalling loss of life in New York and Newark fires it may appropriately be noted that a sprinkler equipment serves as a most efficient life-saver as well as protector of property and had either of these buildings been equipped the gruesome results would have been averted. The same may be said of the Iroquois, Boyertown, Collingwood, and many other fires which stand forth prominently among the extended list of calamities of this kind in our country. The Slocum disaster would have also been prevented, and in fact many passenger boats have since that time been protected with sprinklers. In the experience of the mutual companies there has never been a loss of life in a factory fire where there was a sprinkler system in operating condition. It is apparent that the day is not far distant when legislation will enforce the intelligent use of sprinklers where conditions lend themselves to the occurrence of such accidents.

The National Fire Protection Association, organized in 1896 for the dissemination of knowledge regarding fire protection, is composed of members from nearly all important insurance organizations in the country and has done a remarkable work through the broad publicity given to these matters.

When the mutual companies were organized the stock rates on that class of property were in the neighborhood of $2.50, whereas they now write protected properties in the mutual field for about 10 cents, and this reduction is in a sense a measure of the work of the mutual companies, as they have been more influential in bringing about the difference than any other insurance interests. In recent years the stock companies have paid con-

siderable attention to protection of properties in which they are interested, but this has largely been the result of mutual experience and primarily brought about by their competition, to meet which the Factory Insurance Association was organized about twenty years ago. This is a group of stock companies associated for the purpose of handling selected and protected risks, their operations being largely patterned after the mutuals in such vital features as protective equipments, inspections, plans, and even rates, the latter being pretty consistently reduced, following the experience of an increase in dividends by the mutuals. It is perhaps unnecessary to suggest that voluntary reductions are not in their line, but concessions are made rather in a desperate attempt to secure or hold the business. This association does not present itself to a risk with an established rate as long as the local agent can control the situation, but his instructions are to throw up his hands and call for assistance if the mutuals appear on the horizon and there seems a tendency on the part of the assured to stampede in their direction.

In general, fire insurance differs from life insurance in several essentials, not the least of which is that the latter handles only standard lives and can therefore determine averages more exactly, but the mutual companies have more nearly approached this condition than has any type of fire insurance. The underwriter and the physician both cure the respective ills brought under this skillful attention, and it is the tendency for both to become more and more interested in the prevention of those ills.

The expense ratio is the direct result of management and is commonly beyond direct control by the assured, except recourse be had to the mutual companies. Self or mutual insurance is thus in a sense a reproach on the management, as is pretty well brought out by the fact that the expense ratio with mutual companies is about one-sixth of that with the stock companies. Aside from this, whatever is to be gained by mutual insurance is chiefly due to the fact that the assured themselves have invested capital in the insurance business. The operation of the mutual companies is in the hands of a board of directors who are themselves heavily interested in the insurance on their own properties, thus actuated by selfish motives in addition to whatever others they may have, and therefore keen to detect leaks and extravagances which would

extract dollars from their own pockets. With this supervision it is a natural consequence that the mutual salaries are not fancy, nor are their expenditures in any department unwarranted.

A feature of the stock companies' expense which the mutuals eliminate entirely is that of commissions, varying from 5 to 25 per cent., or even 40 per cent. in extreme cases, and may be taken at an average of about 15 per cent. of the premium. The mutuals do their work direct from the main offices without the intervention of the middleman, and, any one having experience with both systems can appreciate the advantage in this condition. The agent system has other bad features, as he is commonly not as interested as the companies in the reduction of fire hazards, involving as that does a reduction in rate and therefore in his commission. A commission based on earnings rather than on premiums would seem to be more equitable, as removing the purely selfish side of the agent's disposition and making his emolument depend on the underwriting results of the companies he represents. Too many agents competing in one field lead to rebating and other inequitable discriminations.

Contrary to the usual understanding the agent is really the representative of the assured rather than of the companies, although directly paid by the latter. If enterprising and efficient he will look out for the interests of his clients and his expert knowledge is of great value in all questions bearing on the rights of the assured under the policies, but the unfortunate fact is that all are not so, and, as the assured's interests are largely in his hands, there is a considerable element of chance as to the quality of service secured. The mutual companies are at all times in direct touch with the members to advise or instruct and the service is therefore more uniform and likely to be in every way superior.

The feature of rates is a most perplexing one, as it is utterly impossible to deal equitably with all, and even to approximate this is extremely difficult. The price of a manufactured article is largely fixed by the cost of production, while the buying price determines the selling price in a trade commodity; but there is no such guide in fire insurance, for the rate has to be fixed in advance of the fire and based upon an expectation which in turn can only be based upon past experience. When future experience shows this to be wrong further complications arise, but in general the

tendency is to place the rate high enough to secure profit in any event. Progress in protection, change in conditions of manufacture or character of a locality, or an occasional conflagration may enter into and upset calculations and established laws of averages. Combinations of companies for fixing rates seem desirable, for the ease with which companies may be handled would prevent undue tendency to excessive profit, while the combined statistics of many companies, if carefully scanned and properly interpreted, would go far to establish true averages and thus largely eliminate the uncertainty which has now such a great effect upon the rate. Fire loss being an uncertain quantity leads to the taking of unwarranted chances under too sharp competitive conditions and rate wars between companies are dangerous to the community, as the assured may then get his insurance too cheaply, and nothing tending towards inferior protection can be for the public good. Rating by schedule, in which the desirable features of a risk operate as a credit while the hazardous features constitute a debit, is most equitable and tends to encourage good building and the reduction of fire waste in general, but such a schedule must be compiled and adjusted from a mass of facts and long experience. As a rule, and for rather obvious reasons, rates on desirable risks are likely to be too high and on the undesirable too low for such absolute equity, as should really be the ruling consideration, since insurance is in a sense a tax.

These several phases of the rate question are not in evidence with the mutual system, as their risks are selected and the standard of protection serves to further level inequalities of loss. As they are not in business for the purpose of profit, the tendency to charge what the traffic will bear is eliminated and the chief aim in fixing a rate is to treat all with equal justice. There is naturally a variation in rates between different classes and individuals in those classes, but the endeavor is to base them on experience, so as to be fair to all concerned. Even under these more nearly ideal conditions there is bound to be inequality in some degree, but with the low cost involved this is not serious as far as dollars and cents are concerned and is therefore never the cause of much dissatisfaction. It is not at all uncommon for a rate to be voluntarily reduced by the mutual companies when improvements, changed conditions, or favorable inspection reports

indicate such action to be warranted. In general, the range is from 35 cents per $100 on the best storage buildings to $1.50 on plants of the lowest grade, which are still eligible for membership with the companies, the average being about 76 cents.

It may be of interest to compare results in the mutual system with flat rates such as are quoted by stock companies on the same class of business. Assuming a round figure of 80 cents as initial premium with a 94 per cent. dividend, the net cost would be 4 8-10 cents, and to compare this with, say, a 10 cent stock rate, it would be fair to add an item of interest on the difference between the premiums, say, 6 per cent. on 70 cents or 4 2-10 cents, making the total cost for comparative purposes, 9 cents. The mutual companies have recently inaugurated a system of writing three-year policies under the same premium as formerly applied for an annual term, and although the dividend, being effected by three years' losses and operating expenses, will naturally be a less percentage of the premium than on the annual basis, economies to be effected in taxes and clerical work will make the net result more favorable and it is calculated that the three-year policy will show a saving of roughly 20 per cent. of the cost under an annual policy. By this plan, then, the net cost would become about 3 8-10 cents, and adding an interest item as above noted the result would be practically the equivalent of an 8 cent flat rate, or a little more favorable than a 25 cent rate for three years. As the above calculation is for a rate higher than the average, it is evident that on superior properties entitled to more favorable rates, the net cost would be even less and on many mutual risks the results are equivalent to a 6 cent or 6½ cent flat rate. When the cost is reduced to such low terms, the difference in results does not amount to much in dollars and cents but the advantage is commonly on the side of the mutual proposition by 20 per cent. or more, and the average fair-minded manufacturer seems disposed to think it is up to the stock companies to at the very least show an equally advantageous proposition if they are to be considered in equity entitled to the business, so in cases decided strictly on merit the mutuals usually secure it, even under the keenest competitive conditions.

The fact should not be lost sight of that the mutual policies include sprinkler leakage indemnity to the full extent of the fire

insurance and without extra premium, which is not commonly a feature with the stock companies.

The general terms to the policy contract are usually prescribed by law and these are modified, to fit special conditions at a given risk, by a so-called form or rider which is attached to the policy and takes precedence over the wording of the policy itself in whatever features are modified by it. A standard policy was adopted in Massachusetts in 1873 and in New York in 1866, and several other States have since adopted the idea. The New York form is as a rule used by stock companies in such localities as have no special legalized form, but the mutuals use the form prescribed by the State in which they are incorporated, except for risks located in Massachusetts and New York, where outside companies adopt the form prescribed by the respective State. Uniformity in the wording is without question a benefit, as to the average individual the intricacies of an insurance policy are beyond comprehension.

The mutual companies commonly write a blanket form covering buildings, stock and machinery, together with property in the yard, although where the stock is peculiarly subject to water or smoke damage this is sometimes written separately at a higher rate. The aim is to furnish their members the most complete protection in the simplest possible manner and without the use of trouble-breeding technicalities. The co-insurance clause is not commonly employed. By this the assured agree to maintain an amount of insurance aggregating at least a certain specified ratio of the value of the property on the day of the fire, and failing to do so become co-insurers to the extent of the deficiency; that is, they assume the position of another company carrying the balance and therefore sharing proportionately in the loss. For this is substituted the so-called minimum clause, under which the assured agree to carry at least a stated fixed sum in insurance, and although this may be, and usually is, arrived at originally as a ratio of the value, it does not so appear in the policy, so if the total insurance equals the stated minimum, full remuneration will be forthcoming in event of loss, regardless of the cash values of the property at the time of the fire, or any fluctuations which may have taken place since the policies were written. This has been found to eliminate one of the most prolific sources of disagree-

ment over adjustments, but would not be as readily adaptable to the business of the stock companies, where high rates or the moral element might incline a party to put on partial insurance, which, if at the same rate as full insurance, would obviously not be equitable, for if one man carried 25 per cent., another 50 per cent., and still another 100 per cent., according to their several ideas, the chance of a partial loss to the property causing a total loss to the company would work a hardship on the latter. They are therefore justified in securing a higher rate for partial insurance on account of this greater risk, when the co-insurance clause is omitted.

As noted above, the mutuals include under their policies insurance against damage caused by the leakage of water from the protective equipment upon the property insured. The data which has been accumulated as bearing on this class of losses is pretty good indication of the reliability of a modern sprinkler system; for instance, last year 150 sprinkler losses were paid in the 2,600 mills insured, and it is estimated that there were about six million sprinkler heads over the property involved, so only one head in forty thousand caused damage serious enough to warrant a claim on the companies.

Any policy issued by the mutual companies may be canceled on a pro rata basis, on request of the assured, at any time after it has run three months. This feature admirably adapts the system to the covering of fluctuations in value during the life of the policy, which may be followed by changes in the amount of insurance, from time to time, as conditions demand. This is not usually possible under a stock policy without financial disadvantage, as their cancellations, when short of expiration, are at short rates.

The disposition toward the assured in adjustments under the mutual system is well brought out by their unique record of never having undergone a lawsuit or lost a member through dissatisfaction over a settlement. With the stock companies recourse is had to law in about one-half of 1 per cent. of the adjustments. The moral element enters here again, but this difference is mainly due to diversity of motives, the stock companies being in business primarily for the purpose of paying dividends to stockholders and consequently vitally interested in settling for the least possible amount, whereas the mutuals are simply paying out money which

has been previously deposited with them for the express purpose of handling losses, and the officers of the companies consequently have no selfish interest in withholding a single dollar which justly belongs to a sufferer. The province of an adjuster is therefore to assist the assured in determining his amount of damage, rather than attempt a settlement for the least amount possible without serious friction. As no policy may be said to have performed its full office until an adjustment is made under it, a more or less favorable result, from the standpoint of the assured, when large values are involved, may be of more real importance in determining his actual cost of insurance than a mere matter of original premium rate.

The item of profit with stock companies being the prime actuating motive, the cost to policyholders will, in the long run, be adjusted to secure favorable results for the stockholders. Besides capital stock the best companies have a large surplus and unearned premium reserve invested, upon which a comparatively low rate of interest will pay a dividend on the capital stock without any actual profit on the underwriting operations. For the past twenty years it is said that the most successful companies have earned no more than 10 per cent. profit from their underwriting, which is really not an excessive amount, considering the risk, if equitably distributed over the community. With the mutual companies there is no profit to any one except the assured, but it is calculated that had a factory been insured with these companies since their organization, the saving in insurance cost, if capitalized, would at the present time more than equal the total value of the property.

The United States Government controls property aggregating some three hundred million dollars and is annually building about twenty million dollars more. The cost of insurance on this property at prevailing rates would be about $600,000 a year, so they have made careful study of construction with a view of reducing the fire risk and carry their own insurance, thus essentially constituting a mutual company. In the matter of fire-resisting construction the Government is undoubtedly far ahead of the people, but it may be a question whether there are not instances in their buildings where destruction of combustible contents would involve heavy loss, even if the building itself is not seriously damaged.

The New York State Capital at Albany was termed a fire-proof building and deemed so safe that no insurance was carried, but the presence of inflammable contents was apparently wholly lost sight of and unprovided for, with the result that the fire approached a total loss to contents in the compartments involved.

The healthy growth of any business enterprise may be taken as a pretty safe measure of its stability and the following figures, for five and ten years past in the manufacturers' office, are rather enlightening and perhaps indicate that the manufacturing world at large is awakening to a knowledge of the advantages to be secured by insurance under this system.

		Gain	Per cent.
Amount at risk, December 31, 1900....	$234,534,207		
Amount at risk, December 31, 1905....	382,707,750	$158,173,543	70.45
Amount at risk, December 31, 1910....	711,018,427	486,474,220	216.69

That this has not been done at a sacrifice of standards is shown by a comparison of fire losses for the same period.

Amount of losses during 1900............................	$125,036.97
Amount of losses during 1905............................	145,053.00
Amount of losses during 1910............................	156,476 97

	Per cent.
Per cent. of loss to amount at risk during 1900..................	.0557
Per cent. of loss to amount at risk during 1905..................	.0379
Per cent. of loss to amount at risk during 1910..................	.0220
Per cent. of losses to net premium income during 1900............	7.06
Per cent. of losses to net premium income during 1905............	4.67
Per cent. of losses to net premium income during 1910............	2.85

That the expense ratio has been carefully considered is indicated by the following:

	Per cent.
Per cent. of expenses (exc. taxes) to net prem. inc. during 1900....	4.62
Per cent. of expenses (exc. taxes) to net prem. inc. during 1905....	3 92
Per cent. of expenses (exc. taxes) to net prem. inc. during 1910....	3.49

The financial strength of these companies is self-evident from the following extract of their latest annual statement.

Total insurance in force, December 31, 1910.............	$711,018,427.00
Net premium income for year..........................	5,443,770.07
Interest upon investments............................	259,512.21
Total receipts for year (premiums and interest)...........	5,703,282.28
Losses incurred during year...........................	156,476.97
Administration expenses, engineering and inspection expenses, and taxes for year..............................	348,143.47
Net cash assets (including reserve)......................	6,176,258.77
Reserve required by law..............................	2,708,102 66
Surplus in excess of legal requirements..................	3,468,156.11

A rather interesting feature of this statement is the fact that the interest income from invested assets was considerably more than sufficient to take care of the total losses incurred and this has been true for a number of years past.

To sum up the possibilities of cost reduction, the assured may directly control the situation by high-grade construction, careful management, and efficient self-protection; and indirectly, if the property is within the scope of the mutual system, by the elimination of the conflagration tax, moral element, managerial extravagances and excessive profits, for these latter will be avoided whether or not the insurance is actually placed with the mutuals, as theirs is the only real competition which the stock companies experience, and they therefore occupy the rather unique position of fixing not only their own rates but those of their competitors, standing constantly between the assured and arbitrary manipulation of rates which might otherwise be imposed upon them.

CORE ROOM PRACTICE.

By E. A. Coleman, Cleveland, Ohio.

This paper is written from the engineer's point of view; it deals with the tools and equipment the core maker uses; not with the manner in which he uses them, or the methods he has for making cores.

The temptation is strong in places to stray from the text and take up the interesting things in connection with core making, but the result would be a volume instead of a paper.

The core making department includes all the various operations from the preparation of the sand to the delivery of the finished core to stock ready for the molder.

It is necessary to consider the remarkable changes which have taken place in the foundry during the past few years, to appreciate that the making of cores has more than kept pace with the co-ordinate branches of the foundry business; in fact many problems successfully solved by the modern foundryman were unsolved until the core maker gave the answer.

The advancement in the art of core making is all the more remarkable, when it is considered, that while the foundry as a whole has had a hard struggle in most cases to get ahead, yet the poor, despised core room has been the rubbish can, the dump, anything you want to call it; it was a nuisance which could not be eliminated. The statement may sound foolish, yet the writer is willing to wager that many a foundryman a few years ago could not tell where his so-called core making department was located.

If the core makers ever adopt a patron saint, I would suggest she be called "St. Auto," for it is the automobile engine which has given the wonderful impetus to the core making industry; when the tale of the automobile is told and the man behind the casting gets his credit, then it will be known that the core maker, be he ever so humble, has contributed the skill and found the knowledge that made the engine live and the auto have its being.

Probably many a core maker will smile at this somewhat flowery point of view; but let the core maker stop and rise above the apparent level, daily grind of work, to turn backwards and view the place from whence he started; then perhaps he will agree, that after all he has done a great work; he has been moving upwards; he has not only solved many hard and appar-

FIG. 1.—PNEUMATIC RIDDLE AND CENTRIFUGAL SAND MIXING MACHINE.

ently unsurmountable problems, but in doing so he has changed the old drudgery of core making into a fine art; he has transformed the old degraded core room into a modern work place, where working conditions have been wonderfully improved to the advantage of both the work and the worker, where the equipment—but there was not equipment in the old days—the present equipment is all modern; if it is not modern it is not equipment;

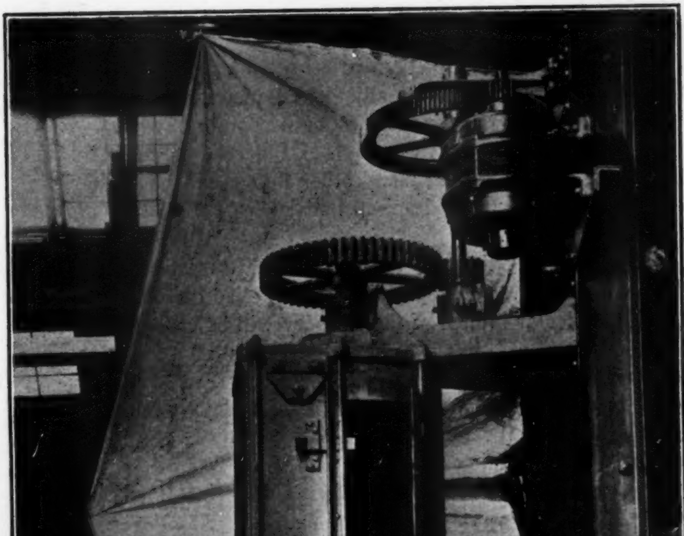


FIG. 2.—MOTOR DRIVEN BATCH MIXER.

the old things, or methods are dead and buried; the core maker is getting each day to be more of a practical scientist; he is learning the "Why" of things.

The old hit or miss methods of core making are doomed and, to-day the core maker and his ally, the engineer, are busy investigating the new things heretofore thought not worth while.

Soon we will know the secret of the relation between the core binder and the sands; many other things will be made clear and very soon one more despised and lowly craft will be raised to where it belongs.

In speaking of the core room, we have in mind the place or places where the various operations are carried on.

No particular branch of the foundry will be considered, only the work in all of its branches contributes all of the things mentioned.

For the purpose of this paper, the core department consists of the equipment, the arrangement, or location of the equipment, and the space for doing the work.

If we forsake this definition, then we get into methods and management.

The equipment consists of devices for preparing the core sand, for making the cores, for baking the cores, for performing other operations using the baked cores.

The space for doing the work provides for storage of the core sands, storage of the fuels.

Place for the equipment, place for the workers, places for core storage, places for keeping small tools, equipment and supplies, place for sanitary conveniences.

The arrangement of this equipment and the location of the various spaces with respect to each other, comprise what might be called the physical core department; it is the core department before operations have begun; it is the body without the soul.

Taking up the equipment for the core making department, it will be conceded that the proper preparation of the core sand is the first consideration; in fact in many cases it is vital. We know this from practical experience, and we are now beginning to understand why it is so.

The sand preparation being important, it would seem to be the logical thing for the core maker to determine what sand is

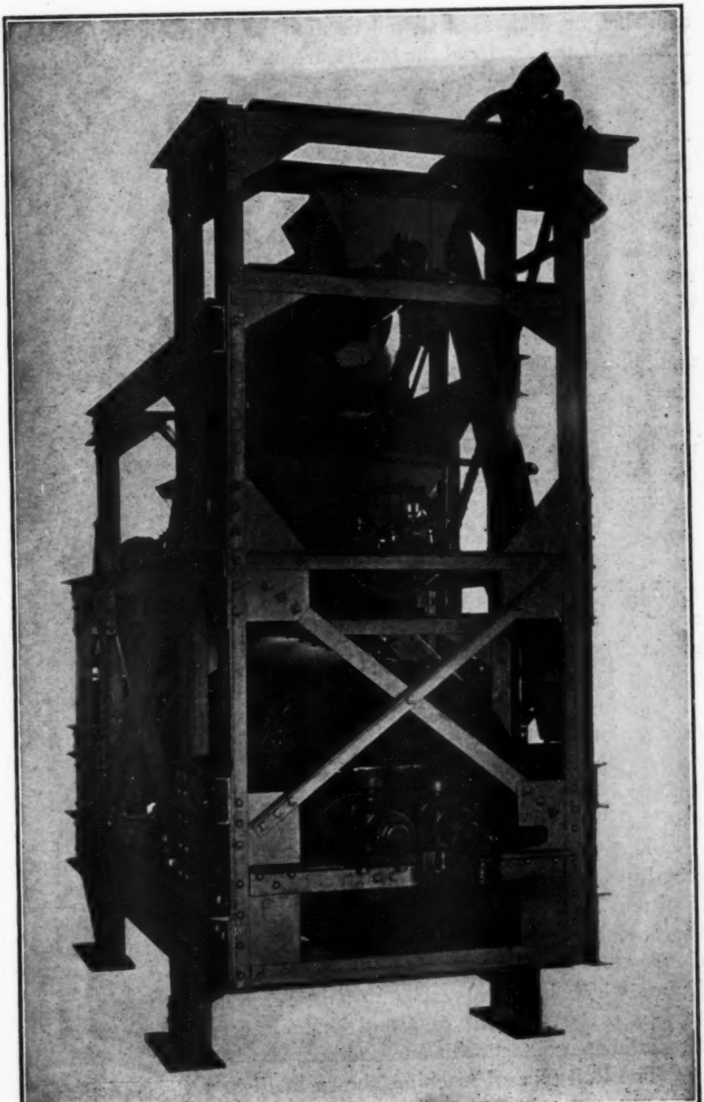


FIG. 3.—SAND MIXING AND BLENDING MACHINE WITH ROLLS.

available, or what sand should be used; and then decide on the binder. If the sand and the binder are fixed, then the problem of determining the equipment to be used is simplified.

The great thing in making good core sand, is to intimately rub the binder all over each particle of the core sand; to thoroughly incorporate the binder and the sand into a homogeneous mass, preferably composed of uniformed sized particles, is what makes a good core sand.

The mere sifting, or riddling together of the ingredients is not a real mixing; it is neither efficient nor economical as to binder.

The statement can easily start a discussion about methods, and because it is such a vital and wonderfully interesting subject, the discussion would fill a book.

Please mentally agree, or disagree with the statement as made, and then arrange for a paper on "Core Sands and Binders" for the next annual meeting.

There are several types of machines on the market for preparing sands for making cores.

The Riddles have screens which are round, rectangular, or cylindrical in form; such machines riddle or shake the sands and the binder together, after there has been a rough shovel mixing, but they do not make a real mixture; Fig. 1 shows a pneumatic riddle.

The Rubbing type of machine first riddles the mixture, and then intimately kneads, or rubs the binder and sand together; this style of machine uses paddles, or screws, which force the mixture, producing pressure, or rubbing by friction, in the mass. Fig. 2 shows such a form.

The Centrifugal type, shown in Fig. 1, depends upon the centrifugal action of arms, or fingers moving at high speed; the sand and binder are first riddled, and as the mixture is fed into the moving fingers, it is broken up a tremendous number of times, the spatter from one finger being caught by dozens of other fingers which in turn break it up; the result being, that all the various particles of the sand and binder are rubbed, or thrown into intimate contact with one another.

The Roll type of machine, shown in Figs. 3 and 4, depends

FIG. 4.—FRENCH SAND MILL AT BAXTER D. WHITNEY'S.

upon the pressure exerted by rolls which rub the particles against each other, also between rigid surfaces: this type of machine also produces a uniform size of grain; the writer thinks it is the coming type of machine. Fig. 5 also shows this type of machine in a small form.

Many of the core sands used contain old, or burned sand; this should be broken up and reduced so as to mix with the other sands.

The use of the old sand is, of course, a great economy, and every foundryman wants to use as much of it as possible.

There is one machine on the market, shown by Fig. 5, which

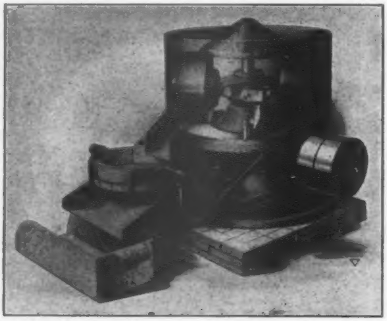


FIG. 5.—WADSWORTH CORE SAND COMPOUNDING MILL.

washes the old sand; the finer sand and burned binder pass off, leaving uniform sized grains as good as new.

Devices for the handling of sands from cars into bins, bins to mixers, mixers to core makers, etc., will be taken up under core room management, since they cut no figure in the equipment required for the actual making of the cores.

The equipment for making the cores consists, in its simplest form, of core boxes which are rammed with sand, the finished cores being baked on core plates, or in forms, or driers, some of which are shown in Fig. 7.

There are also various improved forms of core boxes for making straight or symmetrical cores.

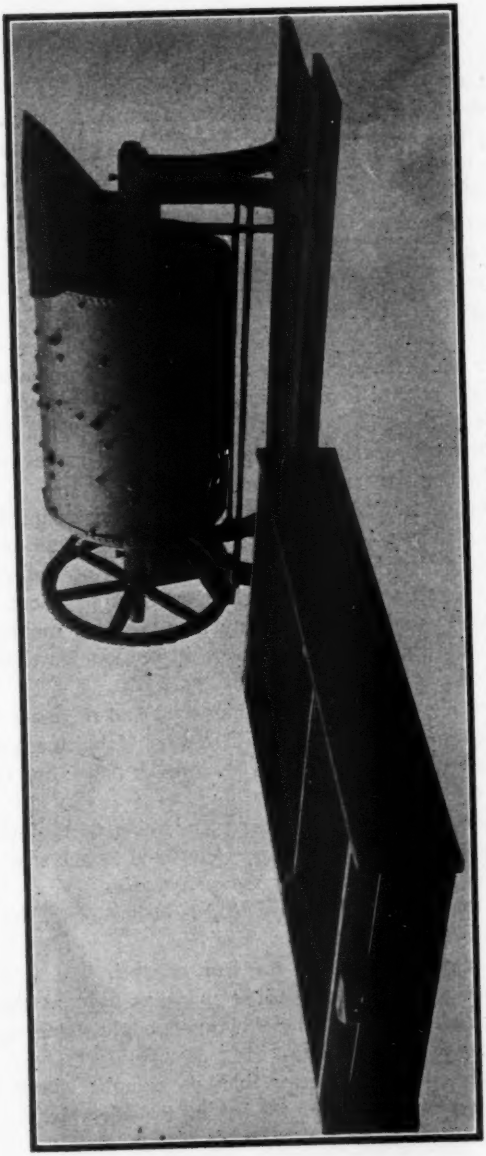


FIG. 6.—CORE SAND WASHING BARREL.

Equipment for Making Cores.

There are machines which make straight cores of various sections which are cut to length; this form of machine uses a screw or plunger and makes either solid, or vented cores; these are shown by Figs. 8, 9 and 10. Fig. 11 shows a cutting off and coning machine.

Special machines for making numbers of cores at a time in gangs are used in a few places.

Core making machines similar to molding machines promise great things for the future.

The Jar Ramming Molding Machine had not been long in use, before the keen-eyed core maker saw its possibilities and now there are several forms of machines depending upon jarring action; one of these is shown in Fig 12 and another in Fig. 12a.

Another type works by compressed air and makes irregular cores by blowing the sand into the box.

The Roll-Over Molding Machines are being adapted to the making of different cores; so are the stripping plate and drop pattern molding machines. Fig. 13 shows the Gow roll-over.

We have seen remarkable changes brought about in the output of the foundry by the many new types of molding machines, and for the same reason we will see similar changes in the output of the core room.

The venting of cores is very important and there are several devices which press vents into the half cores, doing mechanically, better and cheaper work than can be done by hand; one of these is shown by Fig. 14.

The Core plates constitute a considerable part of the core room equipment; the sizes are generally fixed by the sizes of the cores to be baked, especially for the larger cores.

When many small cores are baked on one plate, the plates are made of convenient standard size.

Plates are made either of cast iron or steel.

The cast iron plates should be made as light as the work will permit; ribbed so as to keep down the weight, retain strength and prevent warping.

Machined plates are better than the rough; where vented plates can be used they hasten the baking considerably.

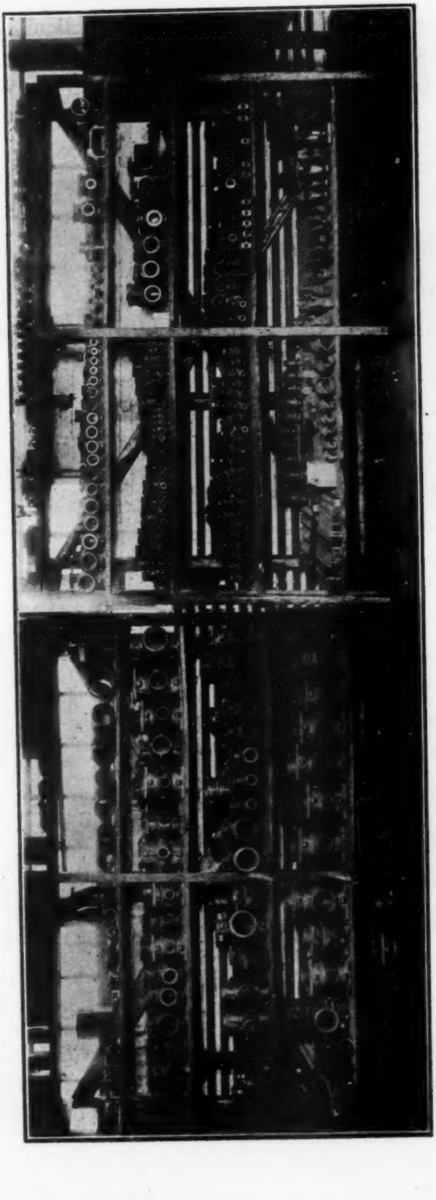


FIG. 7.—CORE BOXES AND DRIERS AT THE GENERAL FIRE EXTINGUISHER CO.

Steel plates are generally flat, or are sections of standard channels cut to length.

There is a limit to the size of plain steel plates due to their warping.

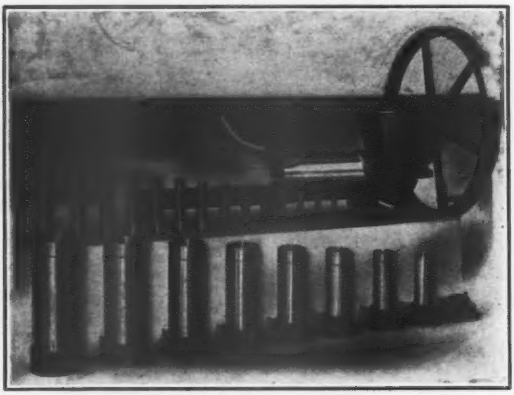


FIG. 8.—WADSWORTH SCREW FEED CORE MACHINE FOR CORES FROM $\frac{3}{8}$ TO 7 INCHES IN DIAMETER.

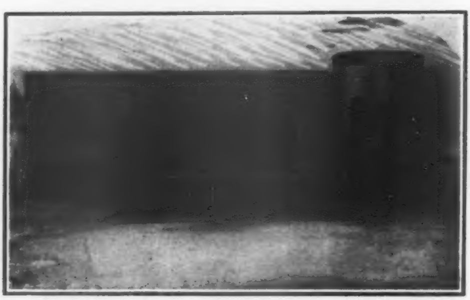


FIG. 9.—WADSWORTH SCREW FEED SLAB CORE MACHINE.

The core maker's benches for small work may be made for a number of core makers, or they may be individual benches.

The individual bench, made with iron frames properly braced, with a heavy working wood top is the best, as it permits a more

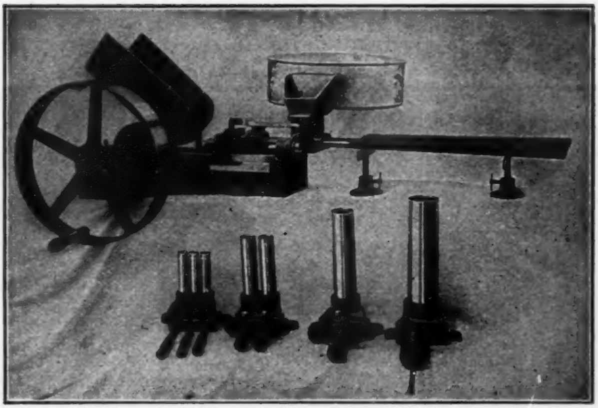


FIG. 10.—ACME PLUNGER FEED CORE MACHINE.

FIG. 11.—WADSWORTH CUTTING OFF AND CONING MACHINE.

flexible arrangement of the core room and furthermore, each worker is not disturbed by the ramming, or rapping at an adjoining bench.

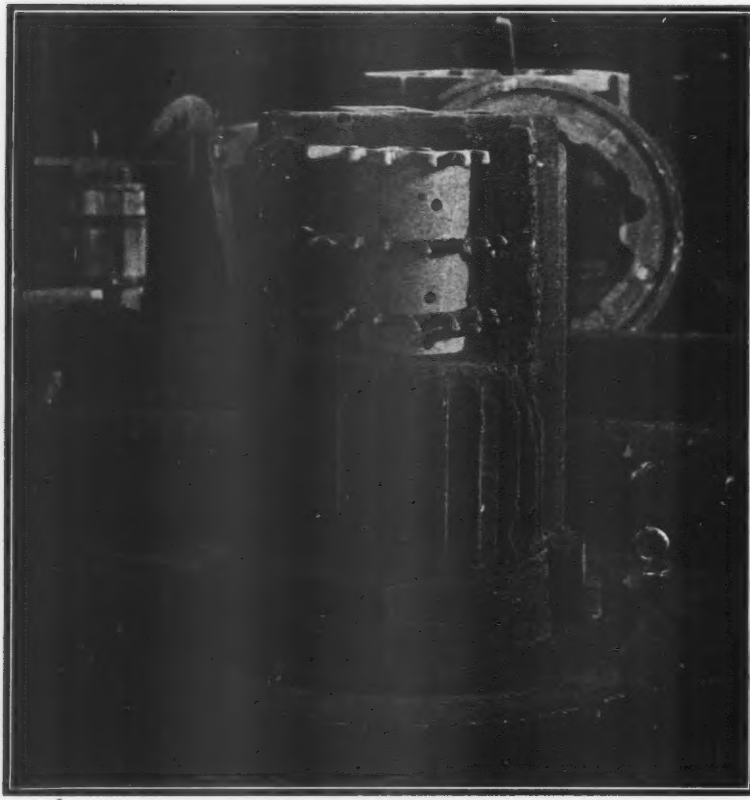


FIG. 12.—TRANSFORMER CASE CORE RAMMED ON A MUMFORD JOLT RAMMING MACHINE.

The core racks are preferably made of steel; but very good ones may be made of gas pipe.

The making of accurate cores is the most important consideration in some shops, and it becomes necessary to test each

part of the assembled core for size; this means the use of gauges shown by Fig. 15 and templates. The assembled core must also be exact, and so there is considerable need for various forms of gauges, calipers, filing jigs, and assembling jigs, as shown by Figs. 16 and 17.

Taking it altogether, it is readily seen that a core department

FIG. 12 (*a*).—WADSWORTH JAR RAMMING CORE FORMING MACHINE.

may be contained in a single room and use only the simplest of equipment; it may range from this to a core department occupying considerable space and requiring a large quantity of equipment and tools.

Considering the equipment used in the core room, there are the core boxes, the core plates, core carriers, driers or forms,

wire straighteners and cutters, rosin mills, blacking mixers, blacking sprayers, or swabs, skin drying torches; there has also come to the writer's notice, a patented device for cheaply and accurately pasting split cores, shown in Fig. 18.

New things are being brought forth each day; they range from the good things down to the worthless things, but they show the awakening of the core maker, and his ambition to improve.

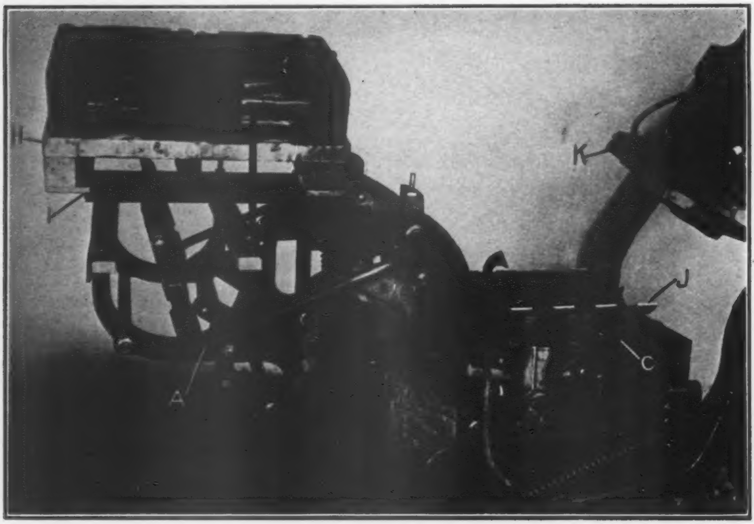


FIG. 13.—GOW ROLL-OVER CORE MAKING MACHINE.

The tendency at first is towards complicated devices for carrying out the core maker's ideas, but practice soon simplifies them.

The writer is a firm believer in simplicity, and has found that the final form of any device having merit is the simplest form of all.

Devices for straightening core wires are important where many wires or rods are to be used.

One type of machine will straighten from one-sixteenth of an inch up to and including three-quarters of an inch, but not in

short lengths. Another machine will straighten short lengths; another one takes wire from the bundle, cuts it to any length up to twenty-four inches and up to one-eighth of an inch in diameter, operating automatically.

There is also the ordinary type of rod cutter for cutting rods or wire to length.

For blacking the baked cores, sprayers of various forms are used; the best ones work by compressed air, though there are several good hand sprayers available.

Natural gas torches working by compressed air and gasoline

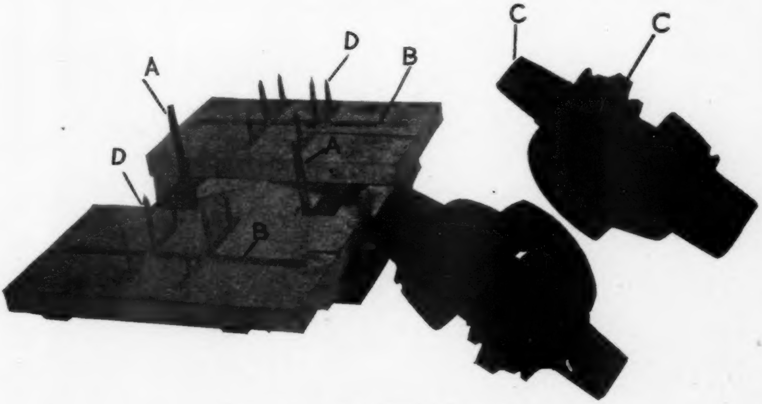


FIG. 14.—GOW VENTING BOARD.

hand torches are generally used for drying blacked cores if they are not dried in the oven, or blacked while they are hot.

The rosin mill is an almost indispensable piece of equipment for grinding and bolting rosin; one make of machine will handle up to two barrels of rosin per day.

Equipment for Core Baking.

The oven for baking the cores was at one time about the only piece of equipment which the core room possessed, and then again it seemed a shame to call it equipment.

The writer could tell many remarkable tales about so-called,

FIG. 15.—CORE GAUGES AND TEMPLATES.

or alleged core ovens, but no good purpose would be served, as they were too horrible to be even bad examples.

One can almost do without anything else in the core room but good ovens; all the core maker's skill will amount to nothing if the oven ruins the good work done.

Ovens should be designed in form to do two classes of work; bake bench, or small cores and floor, or large cores; or we can conveniently divide them into cores one man can handle, and cores requiring more than one man or power to handle.

Taking the ovens for small cores, these are divided into portable and stationary.

The portable oven is made of sheet metal generally with double walls; it may have fixed or movable shelves on which the cores are placed in the oven. One form is shown by Fig. 19.

The openings may be closed with one door to each shelf, one door to a number of shelves, or one door to the entire oven.

The swinging drawer type has shelves which may be either the fourth, the half, or the whole of a circle; each shelf has a closing piece which cuts off the escape of heat, excepting when the drawer is being moved.

There is the rolling drawer type, in which the drawer is drawn out in some convenient manner; it has a closing piece the same as the swinging drawer oven; the shelves are rectangular and there is no space lost due to curved edges. The oven shown in Fig. 19 is of this type.

Taking up the stationary oven for small cores, the same form of ovens are available as in the portable class; there is a difference only in the housing. These types are shown by Figs. 20, 21, 22, 23, 24 and 25.

There is the addition of the car type which is used in many cases for cores one man can easily handle; sometimes it is used because of night baking, or for drying pasted cores after assembling, or because it may be thought more convenient.

There is another type of oven consisting of a car, or cage, which is suspended from an overhead trolley rail, being steadied by a bearing running on the bottom rail; the car is run to the core makers, loaded, run into the oven with the trolley, and after baking run to the desired unloading point. This is shown by Fig. 27.

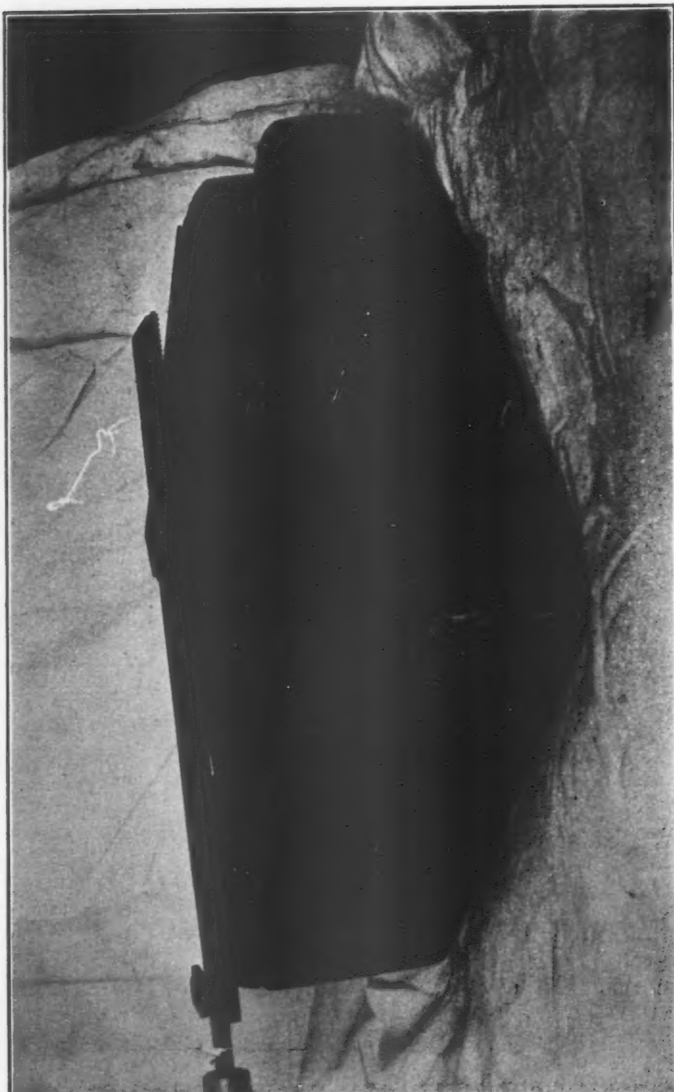


FIG. 16.—CORE FILING JIG.

The continuous core oven handles only small cores, and while it has a limited field, it should be valuable under the special conditions permitting its use.

Taking up the floor core, or large core oven, there is but one general type, and that is the oven using the car, shown by Fig. 28.

The car oven is a brick chamber containing one or more tracks, and a heating system; the openings being closed with some kind of a door; it may be open at one end, or at both ends, so as to pass a car through it.

The tracks are always important in any car oven, and as the loads increase, the greater the need for good tracks; a good track means a rigid foundation, one which will not yield under the loads, or be affected by the heating system.

Too often the track foundations and the heating system are made dependent upon each other; if one part gives out, it wrecks both tracks and heating system.

The rails should be laid level and tied together.

The next important part is the oven door; a door is used to keep the heat in the oven; and should be designed for that purpose; then it should operate as easily as possible; it should be durable and capable of withstanding hard usage and not liable to get out of order; after it is closed it should be tight and not permit heat to leak out.

An insulated door is the most economical to use; it saves fuel, and fuel is the one thing which the oven is always eating up when in operation.

In some places overhead clearance will not permit the use of a rigid, sliding, lift door, and it may be impossible to get room for a side sliding door, and the hinged door takes up too much floor space.

The heavier sliding lift door should be operated by power, and both counterweighted and power operated doors should be provided with safety devices; a counterweighted door is shown in Fig. 28.

The other form is the curtain, or rolling, lift type of door which is much used because of its convenience in operation, easy erection, and compact construction. Two of these doors are shown in Fig. 25 closed.

The cars for carrying the loads require careful construction,

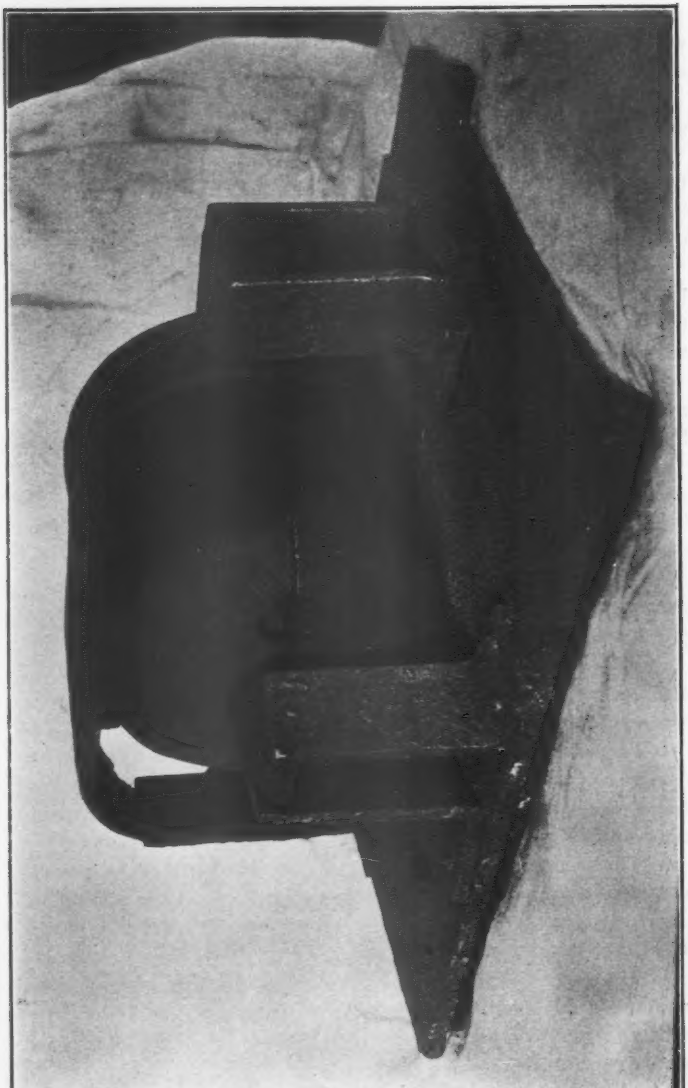


FIG. 17.—CORE ASSEMBLING JIG.

because the core maker can make, or save trouble by using good judgment in their design.

The cars are of the truck, or platform style, or else the shelf, or rack style; or one may be changed into the other; the frames are generally structural steel, but are sometimes built of cast iron especially for very heavy work. Some of these cars are shown by Figs. 29 and 30.

The cars may have plain, roller, differential roll, or ball bearings; plain are better than poor roller bearings.

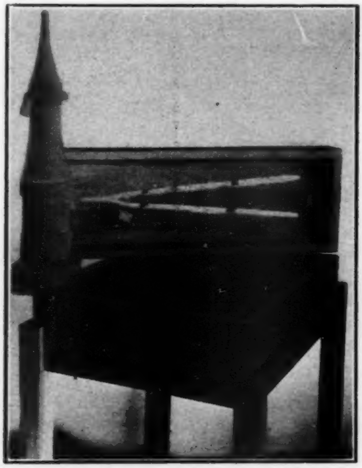


FIG. 18.—CORE PASTING JIG.

The differential roller bearings cannot be used in many cases because of the comparatively long distance the cars have to travel; they are used very little.

By ball bearings is meant the bearing formed by a "V" shaped groove in a rigid rail, a corresponding groove in the rail on the bottom of the car, large sized balls, running in the two grooves carrying the car as shown in Fig. 31.

The power required to move the load with this bearing is small and it keeps the deck of the car down low and thereby gives greater space in the ovens for cores.

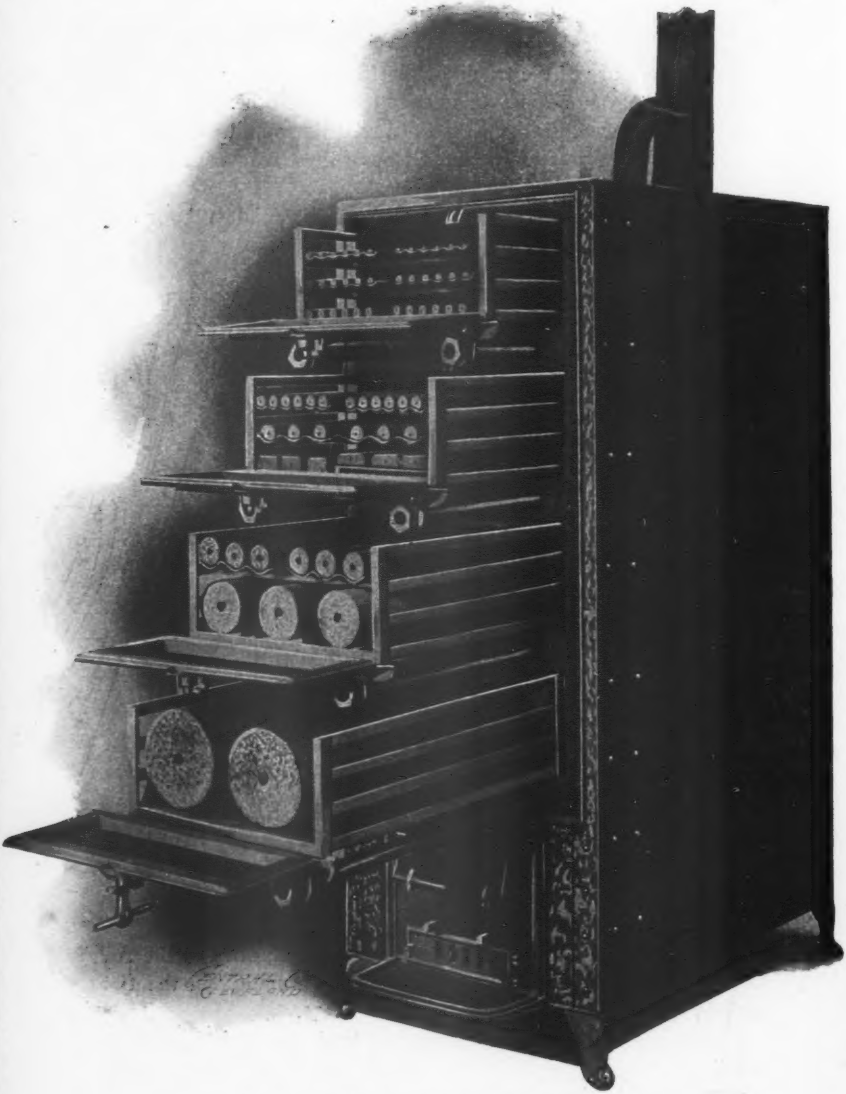


FIG. 19.—WADSWORTH PORTABLE CORE OVEN

In heavy shops using large cars and running heavy loads, handling the cars has always been a troublesome and expensive problem.

The common method is to work the cars into the oven with pinch bars, pulling them out with the cranes.

At the time the cars are being pulled, the cranes are generally needed on other work, and to tie them up drawing cars, in many cases is a serious inconvenience to the other foundry work.

Then again, the ropes and chains broken because of heavy loads on poor cars running on bad or inclined tracks, starts the most Christian core maker to using molder's language.

One large Western shop is using an endless chain which runs into the oven and around an idle sheave at the rear end of the oven; the outer sheave has its top at the foundry floor level, at the end of the run.

The endless chain is driven by a motor under the floor, located in a pit; the chain may be driven in either direction; a dog on the car engages with the chain, pulling the car either in or out.

The driving mechanism is entirely below the floor; by this device one man can pull all the cars from the various ovens; it is expensive to install, but so are all the other good things; it is one solution of a very vexed problem.

Ovens should be built to bake cores economically, both as to time and fuel, and bake them uniformly; the ovens should be designed to withstand the changes due to temperature and the wear and tear of handling the cores.

The insulation should be such that all parts retain the same amount of heat, or so that the losses by radiation are uniform.

The fuels used almost without exception are coke, or hard coal, fuel oil and gas.

One battery of ovens is now being built which is designed to burn coke in emergency, but will ordinarily run on the waste gases from producer fired brass furnaces.

Coke, coal and oil generate the heat at the point where the fuel and the air are mixed and therefore, for good making results, a combustion chamber is required.

Gas may be mixed with the air and the mixture piped to the point at which it is to be burned; therefore, the gas heating is generally a simpler proposition, as good results may be obtained without the use of flues.

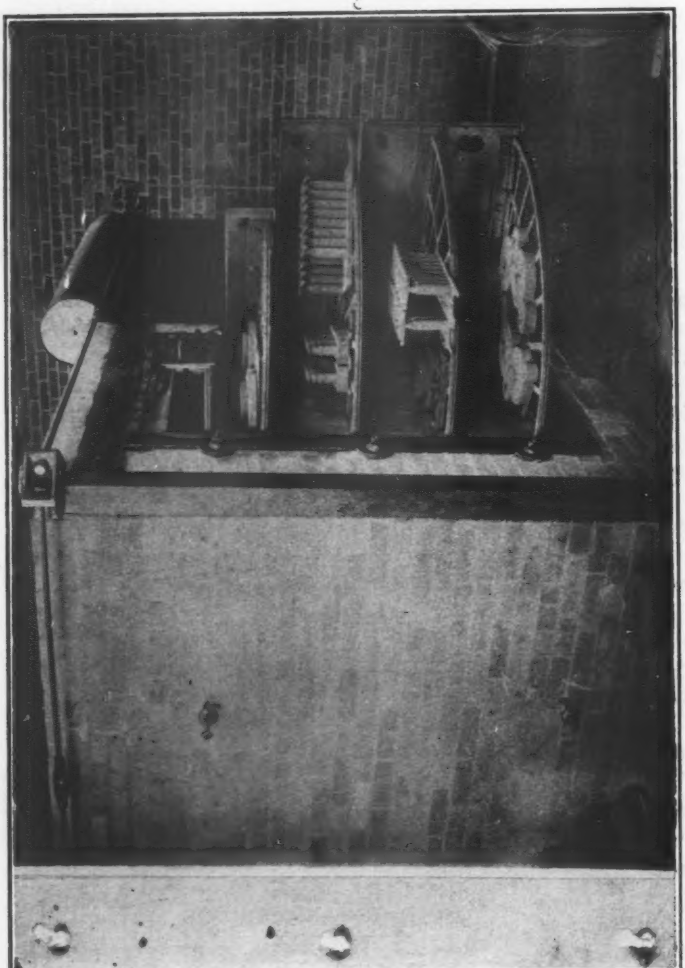


FIG. 20.—MILLETT TYPE OF CORE SHELVES.

The methods used in heating ovens are many and some of them are keeping many a coke oven busy turning out what they consume.

Coke is preferred as being the best core oven fuel.

The heat is dry, since there are no hydro-carbons to form water during burning.

The structure of the coke is cellular and as a result coke when kindled throughout the entire mass produces a steadier heat than hard coal. One type of draft regulation system is shown by Fig. 32.

Oil or gas in most cases is more expensive than coke, but is largely used for various reasons; these reasons are generally local ones, and the fuels are not primarily selected because they are the best for baking cores. Fig. 33 shows the firing boxes located in the basement for heating ovens on the second and third floors.

An oven designed for coke can burn oil or gas, but a gas fired oven should not burn oil or coke; an oil fired oven may burn gas, but should not burn coke.

Sand Storage.

The storage of the sands is very important and in most cases a much neglected subject.

Too often valuable foundry space is taken when properly designed storage sheds or bins are more accessible and cheaper to build.

Sands are generally received by rail, but whether received by rail or wagon, the storage should be convenient for taking in the sands and convenient to the core room, or sand preparation room.

Many problems are complicated by the quantities of sand to be handled; it may be economical to use power in some form to unload the sand from the cars into the storage. Fig. 34 shows one method of unloading sand in a covered storage.

The sands should be stored under cover; where provision is made for keeping out frost, much trouble is avoided, because north of the frost line from four to six months sand must be stored, and where the frost is kept out, time and labor are saved.

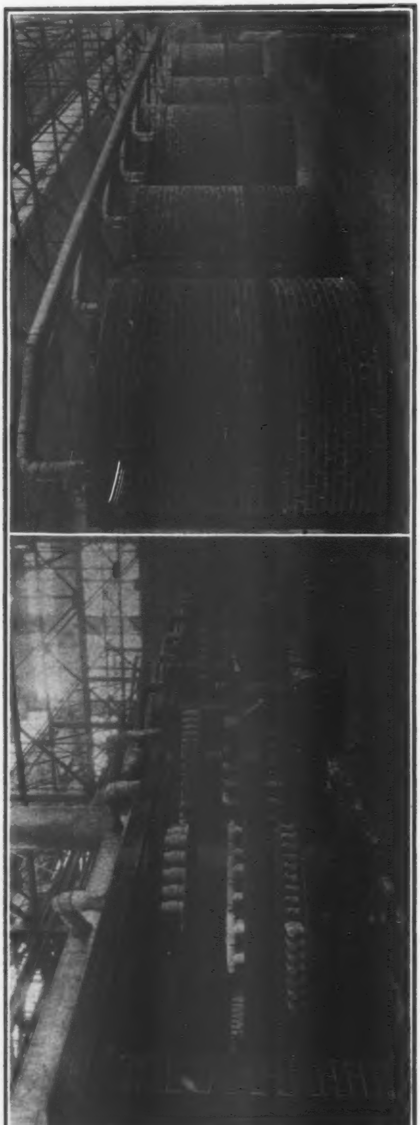


FIG. 21.—REEL OVENS AT THE PLANT OF THE GENERAL FIRE EXTINGUISHER CO.

In many shops sands may be stored on floors over the core department; the sand may be delivered by an elevated track and shoveled directly into the sand bins.

It may be unloaded into binds along the foundry wall, as shown by Fig. 36, or into bins underneath the yard tracks along the wall and accessible from the basement; or they may be

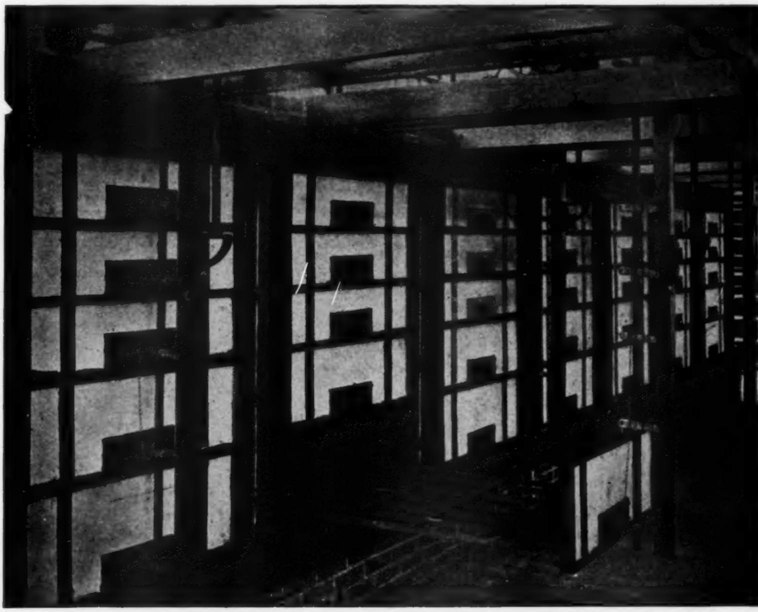


FIG. 22.—DRAWER TYPE OF CORE OVEN.

unloaded into the basement through chutes in the wall at the floor line.

These forms of storage are fine for keeping frost out of the sand and provide a good arrangement where a sand preparation room is used.

Where sands are stored on the floor above the core room, or within easy reach of the core room, they are there prepared and either chuted down to the core makers or else the sand is loaded

FIG. 23.—DRAWER TYPE OF OVENS SHOWING TROLLEY.

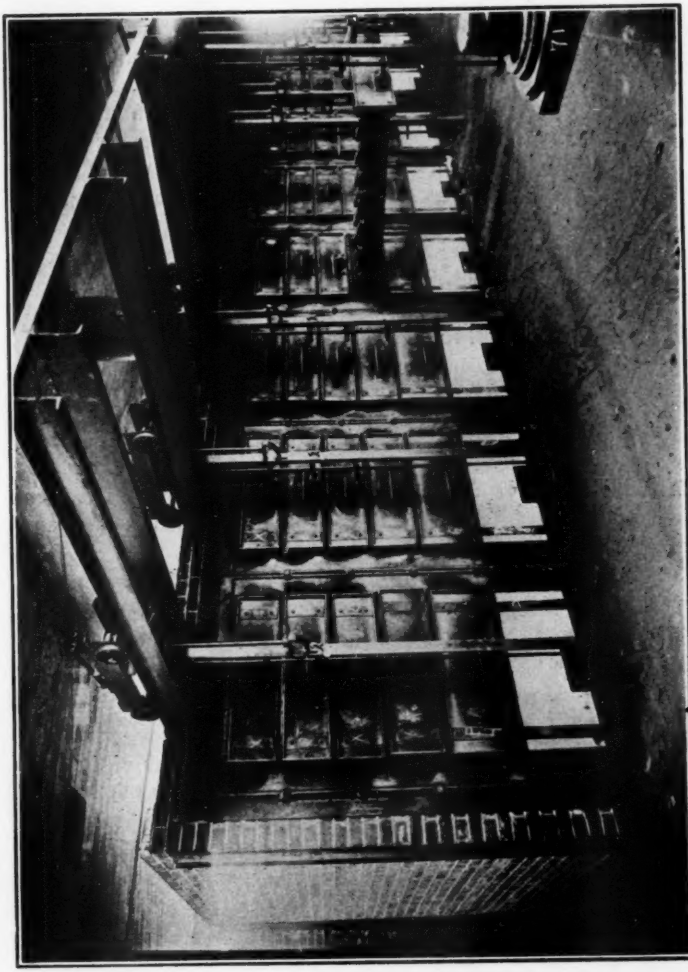


FIG. 24.—DRAWER TYPE OF OVENS WITH DRAWER PULLED OUT.

into buckets, to be handled by crane or car to the places where it is to be used.

Sand storage bins may be made so that the sands are drawn from the bottom, as shown by Fig. 37, prepared and carried to the core room by car, conveyor, or some other device.

Where coke is used as fuel, the problem of storage is generally solved by the storage of fuel for the melting end of the foundry.

Oil is good so far as storage is concerned, because it may be piped anywhere.

Gas is the most convenient of all, since storage is not necessary and it may be piped to any point.

Place for Equipment.

The old saw, "a place for everything and everything in its place," is, of course, true in the core room department.

When core plates, core boxes, driers and all the other tools are considered, it can be readily understood that convenient places for all these things means, not only a saving in time and temper, but a great help in keeping up the inventory of tools and equipment.

No reference is made to the storage of core boxes, since in most places they are a part of the pattern storage, but where stock core boxes are run continually, it is, of course, necessary to provide proper storage for them.

Sanitary Arrangements.

Depending upon the size of the plant and the sex of the core makers, the sanitary arrangements may be the same as those used by the other departments, or one or more separate toilet and locker rooms may be required.

The storage of the completed cores depends somewhat upon the system in force in the foundry.

The cores may be delivered to a separate core room, which is charged with all that goes in, and credited with all that goes out on orders.

In other places the cores are grabbed by the molders while still hot.

FIG. 25.—CORE OVENS WITH ROLLING DOORS.

Most core rooms have racks for the finished cores which may be taken by the molder on order, or which may be sent into the foundry on order.

Core Room Arrangement.

In the small core department, the ventilation and light are two important things. It must be remembered that certain binders

FIG. 26.—CORE OVEN CARS.

produce very disagreeable smoke and gases after the cores leave the ovens, and good ventilation is necessary to produce a comfortable place for the core makers; core rooms with low ceilings or roofs are bad, especially when the core makers work in the same room with the ovens.

Where the core department can be laid out so as to locate the ovens in a room separate from the core makers, better results are obtained, both as to quality and quantity of output, because the core makers are more comfortable. A poorly designed core

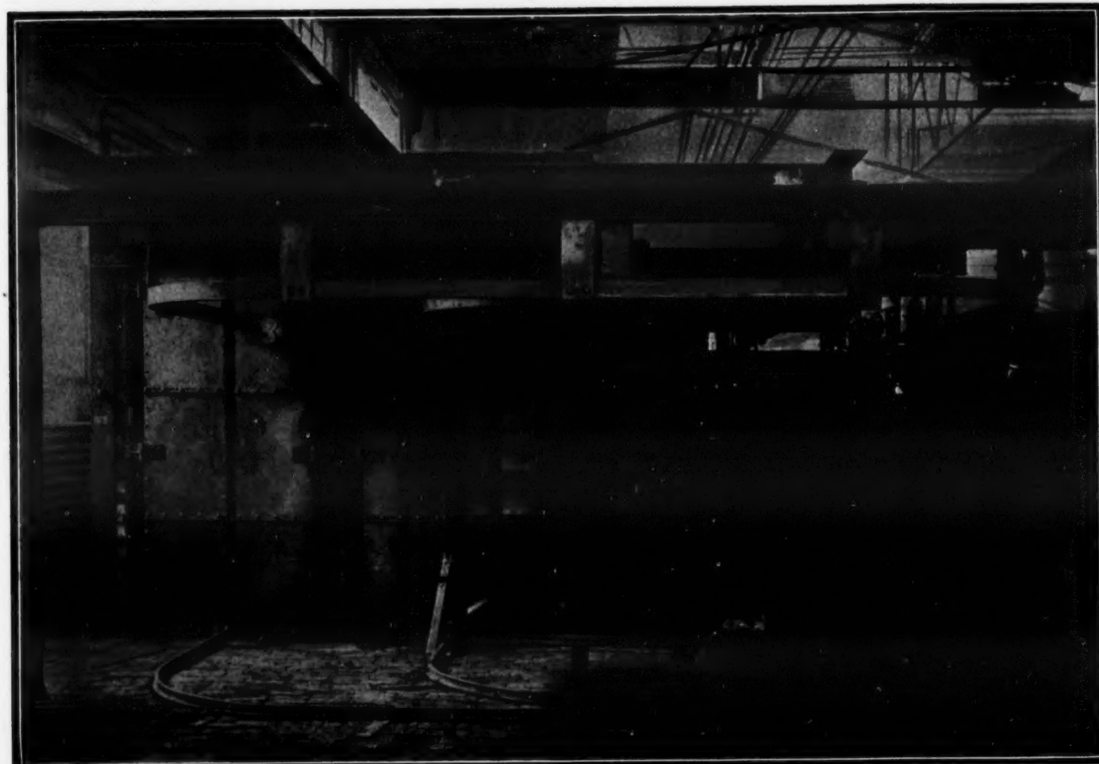


FIG. 27.—CORE DRYING RACKS SUPPORTED FROM TROLLEY.

FIG. 28.—CORE OVEN WITH LIFT DOORS.

room can be about as uncomfortable a place to work in as one could wish, and manufacturers are now realizing that comfortable working places are a good investment.

Most of the statements made relative to the subject of ovens, racks, and storage of cores, relate to small, or bench cores, and in speaking of separate core oven rooms, it is kept in mind that many foundries to-day are employing girls in the core room, but boys and men also show better results in good working places.

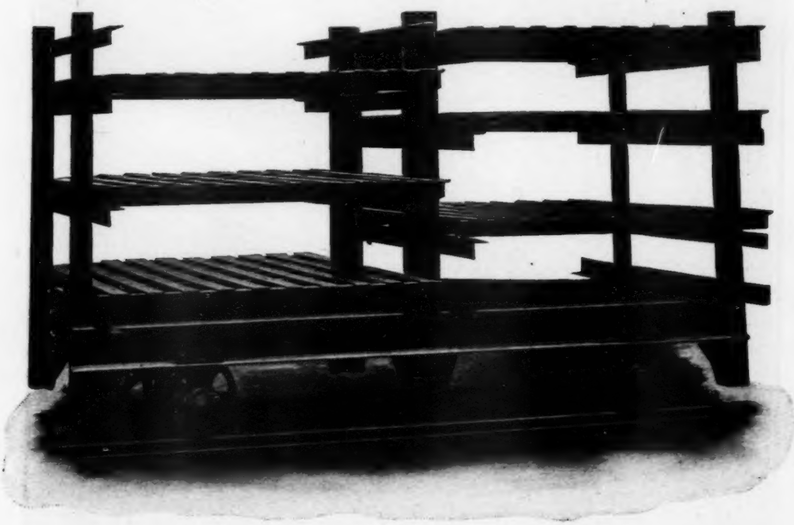


FIG. 29.—CORE OVEN CAR.

The arrangement of the benches, ovens and racks for green cores depends somewhat upon the system of distributing sand and of handling green cores from the benches to the ovens.

If the core makers have the sand brought to them and the finished cores are taken from them by ordinary labor, the benches may be arranged so as to permit the sand to be placed and the cores to be removed without disturbing the core makers.

In many places, the sand is delivered to the core makers, who either deliver the finished cores to green core racks, or tables, or each core maker bakes his own cores.

Passageways should be laid out so as to make it convenient to deliver the green cores to the racks at the ovens, and to handle the sand, plates and boxes.

When the core makers do their own baking, there is not so great a need for the racks at the ovens.

FIG. 30.—CORE TRUCKS AT THE MICHIGAN MOTOR CASTING CO.

When the heavy, or floor cores are considered, it must be kept in mind that generally such cores are made in a side bay outside the range of the main bay cranes, and it is desirable to deliver them directly to the molders.

Therefore, the lay-out should be made so that the finished

cores can be unloaded under the main bay cranes either by running the cars out on the main floor, or else by swinging them from the core cars by jib cranes out on the main floors, or by loading them onto other cars, by the core bay cranes, and then running the cars out under the main bay cranes, as shown by Fig. 38.

Unless there is some good reason, the best arrangement is the first, in which the core cars are run out and unloaded by the main bay cranes, or by the traveling side jib cranes running under the main cranes.

In laying out your core department, remember the great importance of the core room, not only as to arrangement and equipment, but as to practice.

The core room is responsible for its part in making bad castings, and deserves its share of the credit, which it rarely gets, for making good castings.

A foundry operating on a low percentage of loss is a happy place to work, but bad castings are the rheumatism of the foundry.

After you have designed your core department and proportioned the spaces you require for your work, add some more space and don't let any one get it away from you. Take all the space you can get; then insist upon plenty of good light and ventilation.

All kinds of combinations may be made when considering fuels and storages, core makers, equipment, local conditions and the foundry system. There is always one best arrangement, and that, of course, must be found by patient, careful study.

The writer hopes that this paper will be of some benefit to some one; he would be better pleased if the paper were more specific in various places, but the consideration of such a broad field must necessarily result in generalities.

FIG. 31.—HEAVY DUTY CORE OVEN TRUCKS.

FIG. 32.—FIRING PIT AND DRAFT PIPES FOR CORE OVEN.

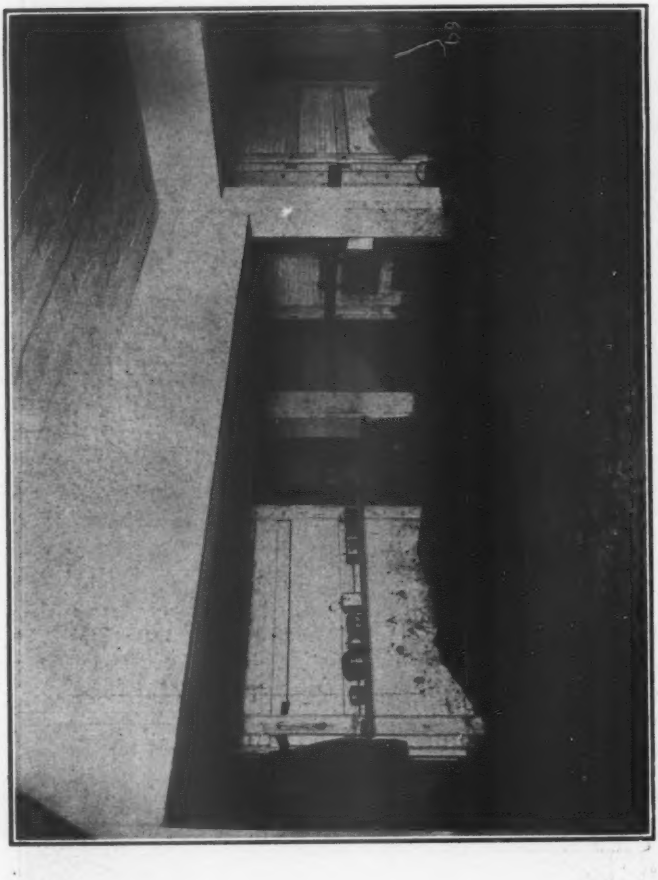


FIG. 33.—FIRING PIT FOR CORE OVENS PLACED IN BASEMENT.

FIG. 34.—SAND STORAGE AT THE BETTENDORF AXLE CO.

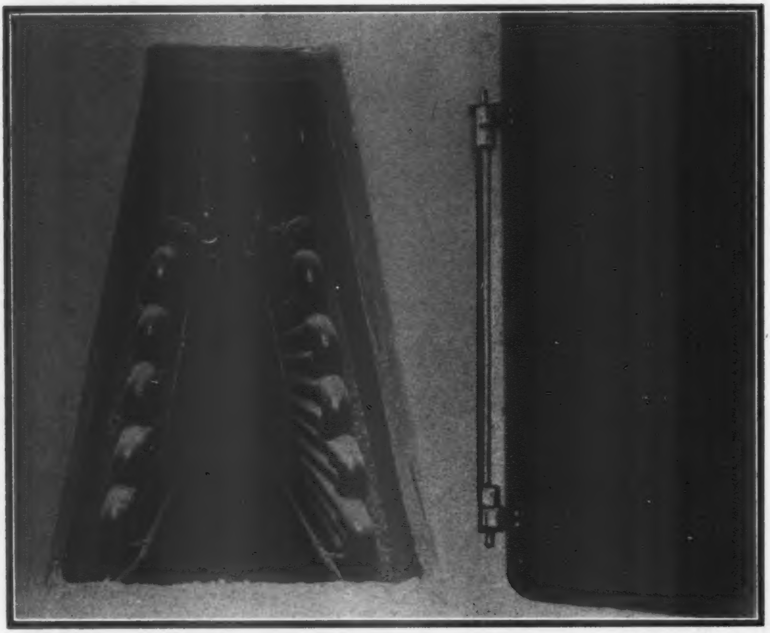


FIG. 35.—HEATING COILS UNDER SAND STORAGE.

FIG. 36.—SAND STORAGE AT BAXTER D. WHITNEY'S.

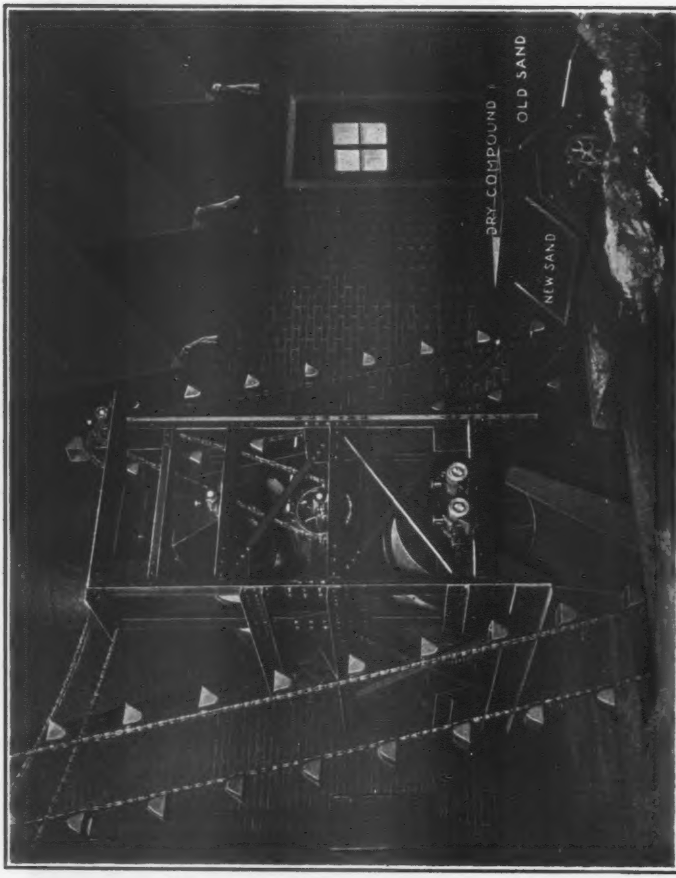


FIG. 37.—BUCKET ELEVATORS FOR HANDLING CORE SAND.

FIG. 38.—CRANE HANDLING CORES FROM CORE OVEN.

DEFECTIVE CASTINGS AND HOW TO HANDLE THEM.

By John M. Perkins, St. Louis, Mo.

This subject is a very broad one, and one on which the success of the foundry industry very largely depends. It is of vital interest to the foundry owner, to his manager, to his foreman and to his molders and coremakers. In fact, there is scarcely an employee in the foundry who does not feel the baneful effect of defective castings.

This, to my mind, is as it should be, and if it spurs each and every one in the foundry to an earnest endeavor to find out the causes and remedies for the bad work, the result will be a substantial decrease in the amount of defective castings.

If, on the other hand, the spirit of the whole organization is to find out who is to blame, or in what department the fault lies, and then to widely advertise the fact that it is up to the poor unfortunate (whoever it may be), and by so doing, apparently ridding themselves of any worry or thought in the matter, although this method may ferret out trouble, its resultant action is to breed discontent, increase the scrap pile and put harmony and organized effort for permanent good results to rout.

This much to show the value of an *esprit du corps* and the spirit of co-operation in any organization.

Let us consider the subject in hand from two viewpoints. First: How to reduce the percentage of defective castings. Second: Having made castings which are not perfect, where shall the line be drawn between those which for all practical purposes are good, and those which must go to the scrap pile.

Taking up the subject from our first viewpoint, let us endeavor to follow a casting from its inception until it is ready for the machine shop.

A casting really starts in the draughting room of the designing engineer's office. Right here is where a great many defective castings are made.

Every engineer cannot be expected to have a foundry experi-

ence, however valuable or necessary to successful work that may be, but he can be expected to keep in touch with the foundry and those interested in its work; in this way, many points vital to the successful making of a casting may be put into a design without injuring the final efficiency of the machine of which this casting may be a part. There are so many minor details, seemingly of no importance to the engineer, but of vital interest to the foundryman in his attempt to make good castings.

These statements apply alike to the engineer who is working with a concern which owns its own foundry and to the independent engineer who simply makes his designs and then the castings are made up in a jobbing foundry. Many of the latter complain that no two foundrymen's ideas are alike. This statement applies equally well to any line of business, and only dodges the issue. Foundrymen, as a whole, intend to be reasonable, and their desire to be consulted comes from the fact that they want to deliver good work, and not in any sense to interfere with ideas and designs which engineers feel will make a successful machine.

The patternmaker receives the drawing from the draughting room, with orders to make a pattern. In looking over this drawing and laying out his lines for the pattern, he notices various things which, to his mind, are not as he thinks they should be. Right here is where the foundryman should be consulted. As a matter of fact, the patternmaker usually turns to the engineer, and between them the pattern is completed and sent to the foundry.

I am very frank to admit that the patternmaker's ideas may be absolutely along the right lines in many instances, but the direct application of these points can be so modified by the foundryman as to save his making a large amount of defective work, and at the same time not injuring in any way the value of the resulting casting. If, however, the patternmaker consults with the foundryman, and all the points of change are decided upon between them, then let the engineer step in and decide what changes and concessions he can make, and not compromise the value of the machine of which this casting is to become a part. In this way such matters as thickness of metal, sufficient draft, necessary stock on finished surfaces, the advisability of casting

separate parts and bolting them together (instead of endeavoring at a comparatively large expense and liability to loss in making one solid casting), the question of green sand or dry sand cores, in one case getting a tapered hole, in the second case a straight hole.

All these and many other difficulties which every foundryman has to contend with can be discussed, and a decision equitable to all concerned arrived at in a manner which will secure co-operation and resulting in good work from the foundry.

After the pattern has been completed and sample castings have been made and checked, it is then up to the foundry to take up the question of production. Right here is another fine opportunity for the spirit and use of co-operation.

In many instances the foundry superintendent will look the job over and decide at once the rigging to be used in molding the casting in question, determine the size of flask, and suggest changes in the pattern which may have come to his observation in making the sample castings.

In my estimation, this is all wrong. It would be far better to call in the coremaker, the molder, the cleaning room foreman—all of whom have worked on the first castings, and without doubt have noticed many little details which would help in making good castings and would be willing and glad to give out their knowledge to the proper individuals. Then, with all this added store of information, the foundry superintendent would be in a vastly better position to decide on the economical and best method of production.

This mode of procedure does not in any way belittle the reputation of the foundry superintendent. In fact, it enhances it, because it shows that his mind is open to improvement and he is willing to learn from the man in more humble circumstances. It is from the minds of our mechanics in the shop that some of the most valuable ideas start.

I know of one firm in Detroit, Mich., which is paying to its employees one dollar for every idea—however insignificant—which it finds advisable to adopt in its shops. This may seem a small compensation, but it is an incentive to offer suggestions and it also gives the firm a clue as to who is using his brains together with his hands.

When the pattern and rigging are ready for production, then comes the actual making of the castings. At this stage the foundry superintendent has to decide matters to a great extent himself, without too much consultation with the shop. This is more or less due at the present time to labor conditions and to the fact that a man will turn out an amount of work under favorable circumstances which almost invariably surprises himself. Thus, in order to get the maximum production on any one job, the foundry superintendent must, from his own experience, gauge what should be its output, and work towards that end. I may have seemed to digress from my subject here, but I wished to bring this to your attention, because maximum production and percentage of defective castings often have much to do with each other.

If a foundry is working piecework and each molder guarantees his work, the defective castings proposition is much simplified. Under these conditions, the molder is paid only for the good castings which he produces and at a stated price for each good casting. This method furnishes a mighty incentive for good work. In some shops, in which there is a strong opposition to piecework, a set day's work is established and then a monthly bonus is paid for low percentages of defective work. In one of the largest foundries in the country a bonus of $15 per month is paid to molders whose work shows less than 2 per cent. loss, $12 for less than a 3 per cent. loss, $10 for less than a 4 per cent. loss, $7.50 for less than a 5 per cent. loss and $3.75 for less than a 6 per cent. loss. It is amazing to see how many men get the $15 bonus. In this particular case, the bonus creates a strong spirit of co-operation. Every one is interested to make the job work perfectly. (The foremen in the shop participate in the bonus system, their bonus being made up from an average of all the molders' percentages.)

In many shops there are what are called "trouble men." These men look over all defective castings and ferret out causes for defects. They see that changes which would stop these defects are made at once, and the causes and remedies applied are brought to the attention of all interested in this particular job. These men are indispensable when they are brought up to a high degree of efficiency, especially in a large foundry, where small defects

are often allowed to go on, sometimes indefinitely, without being remedied. This is the case because there is no one person to stick to the job until it is attended to. Under these circumstances, the services of such men are of great value.

The melting department of a foundry sometimes has a great deal to do with defective work, although in these days of chemical analysis and the use of the physical laboratory, this department has been able to overcome many of its defects.

I do not think I am making a rash statement when I say that any foundry which makes an intelligent use of these two aids in its melting department has any large or continuous run of defective castings on account of its metal. This condition of affairs has, without a doubt, been brought about by a close co-operation between the foundry and the laboratory, and will last just so long as this harmony of action exists.

Having once determined the final analysis of the product desired, under normal conditions, it is comparatively easy to obtain practically constant results because these results depend more or less on the working of a machine, in the shape of a furnace rather than almost entirely dependent on the operation of a human being as is the case in the designing office, pattern and molding shops. These statements are not made with any intention of belittling the furnace platform, but only to show that in the present state of the art, most of the defective castings in a foundry are due to other causes than the melting. Outside of dirty metal, which is generally due to poor raw materials, the pouring temperature is the most important item which has to be dealt with. But with the very efficient and practical pyrometers which are now on the market, this determination is again not subject to simply human manipulation.

A clean shop and well-cared-for equipment tend towards the lessening of the percentage of defective castings; these statements are so self-evident that they only need a passing mention; every up-to-date foundryman realizes their value.

The cleaning and chipping department of the foundry seldom actually make defective castings, but can often spoil the appearance of good castings by poor grinding or chipping. The value of this department is to turn out as comparatively good looking a casting as it receives from the foundry.

Thus far I have endeavored to impress upon you that five facts are essential to a low percentage of bad castings, viz:

First, a design from which good castings can be made continuously;

Second, the combined ideas of all interested in the making of the casting, so as to obtain the best equipment for its production;

Third, a substantial incentive offered for good work;

Fourth, having made a good casting, to have it shipped with as good an appearance (comparatively) as when it was cast;

Fifth, a clean, well-equipped shop, which furnishes an *esprit du corps* among its members.

These five conditions joined together by a strong spirit of co-operation form a mighty bulwark against a defective casting army.

The second part of my subject, "Having Made Castings Which Are Not Perfect,"—where shall the line be drawn between those which for all practical purposes are good and those which must go to the scrap pile,—may be stated briefly as follows:

What constitutes good castings? Any foundryman who has run up against government, railroad, or automobile inspectors, will realize the importance of a practical answer to this question.

I have always contended that these inspectors should be men educated in the foundry, knowing full well that no one outside of the foundry will agree with me. Nevertheless, there is not the slightest doubt but what men fully competent and of the highest degree of efficiency can be chosen from the foundrymen's ranks who will use all necessary caution in inspecting foundry output, who from their intimate knowledge of castings in general will not be influenced by defects which do not impair the efficiency of the castings, and which defects will often appear on account of methods which have to be employed in the foundry at the present time.

In a certain large shop in the East, I have many times heard the statement made that enough castings were scrapped every day to supply an ordinary machine shop. This statement was true. These castings were condemned because the inspector and his superiors did not know the limitations of foundry practice and they worked along lines which it was impossible for the

foundry to continuously follow. I do not think this represents an isolated case.

Here is another opportunity and a large one for more co-operation; this time, between the machine shop, through its inspection department and the foundry; if such can be brought about, it will certainly save many castings from the scrap pile. In this way, the shop will understand the difficulties with which the foundry has to contend and the foundry will work with renewed interest to satisfy the machinist.

The method suggested is most efficient for stopping the needless condemning of castings.

The modern welding machines are doing much good work in saving castings—the electric machines in steel foundries and oxyacetylene machines in gray iron and aluminum foundries. I mention these machines in passing, because they can be and are used, although I think their field is more in cases of breakdown, or in repairing defects in very large castings. In small work, their cost of operation more than offsets the value of their output. The use of these machines so often entails so much preheating and preparation of the defective castings as to render their work too costly.

In closing, I wish to bring to your attention that the main thought which I have tried to bring to you is that of co-operation of all those in any way interested in the foundry and its work. With this as a standard to follow, a low percentage of defective castings is sure to result. This is especially true in the foundry where there are so many loop-holes for mistakes to creep in. For this reason, it is impossible for one man or one department to attain proper results by working alone. By working shoulder to shoulder the foundry's progress will never be halted.

CHEMICAL AND PHYSICAL PROPERTIES OF MALLEABLE IRON.

By W. P. Putnam, Detroit, Mich.

The characteristics of malleable castings are generally well known to those who make them. The users of malleables are not so conversant with the problems involved in their manufacture. The results of work done on annealing malleable iron here recorded may throw some light on the difficulties that must be overcome in manufacturing high grade malleables.

After the iron has been properly melted and cast, the foundryman's troubles are about half done. If the castings are large and do not need to be machined, the annealing process does not present exceptional difficulties in the annealing room. On the other hand, if the castings are small and are required to be machined, the annealing process must be watched very closely to avoid ruining good material. While it is impossible to correct in the annealing process all of the mistakes made in the melting room, it is possible to spoil beyond recall, good metal by improper annealing.

The evidence presented here covers a number of years of experiment and research carried on at odd moments. If there is created any small amount of discussion the writer will feel amply rewarded, for it is only by the discussion of such topics that progress is made.

The woeful indifference sometimes displayed in equipping annealing ovens with pyrometers is, in a large measure, responsible for a large percentage of rejected malleables. In beginning this work I first realized that very little headway could be made without first knowing something of the physical structure of malleable iron as well as its chemical characteristics. Of course, the importance of melting and molding should be given proper weight, but it is with the annealing operation that I wish to deal in this article.

The proper annealing temperatures shown in Plate No. 1 were experimentally determined by placing a pyrometer inside

pots of castings with varying percentages of carbon. These temperatures were subsequently checked up by annealing a full oven with similar metal. By knowing the percentages of carbon and using a pyrometer, one can duplicate results at will, without a variation of great extent and within which malleables can be produced satisfactory in every way.

Plates No. 2 to No. 6, inclusive, show the results obtained in annealing hard iron, or white cast iron in a commercial way. Particular attention is called to the uniformity of results. In every case the castings were satisfactory.

Table No. 7 shows the chemical analysis and physical tests on four samples of malleable iron which illustrates some of the differences between good and bad malleables.

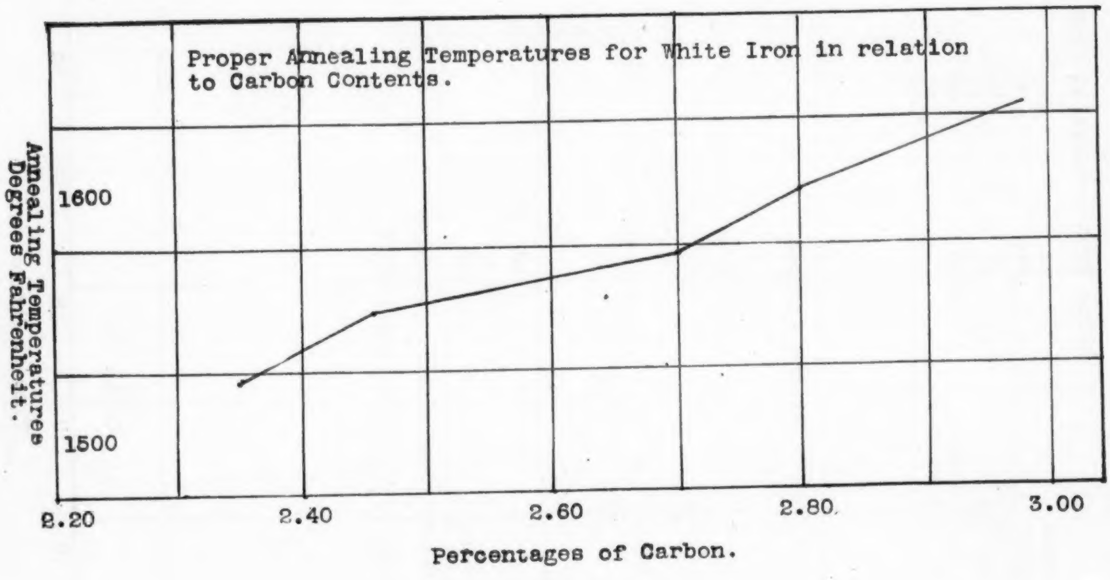

Proper Annealing Temperatures for White Iron in relation to Carbon Contents.
1600
1500
Annealing Temperatures Degrees Fahrenheit.
2.20
2.40
2.60
2.80
3.00
Percentages of Carbon.

Table I.

	White Iron	Annealed Iron
Silicon	.74	.78
Sulphur	.064	.068
Phosphorus	.182	.180
Manganese	.35	.31
Combined Carbon	2.80	.25
Graphitic Carbon		1.62

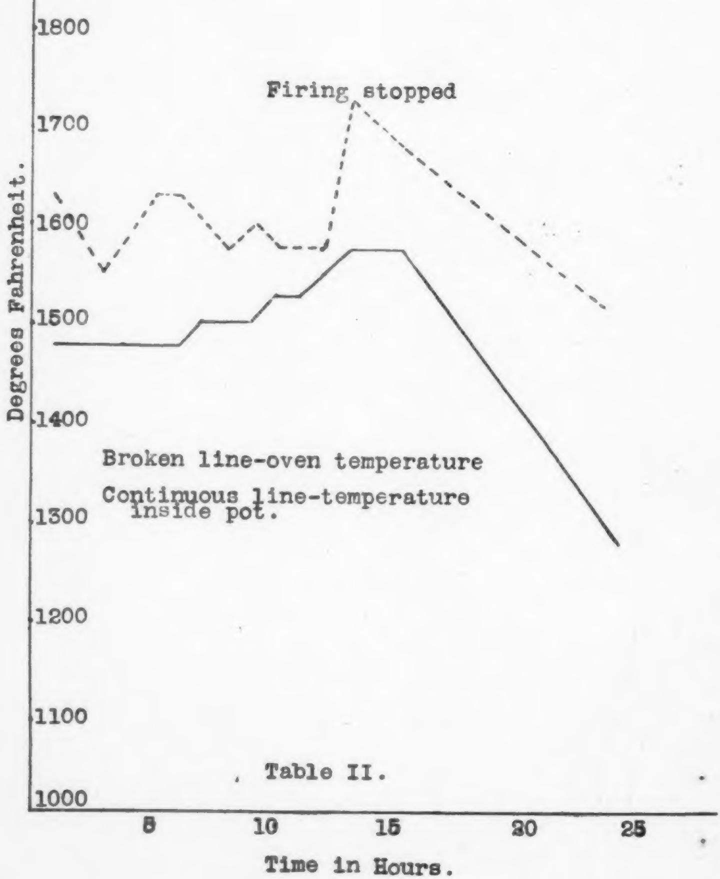
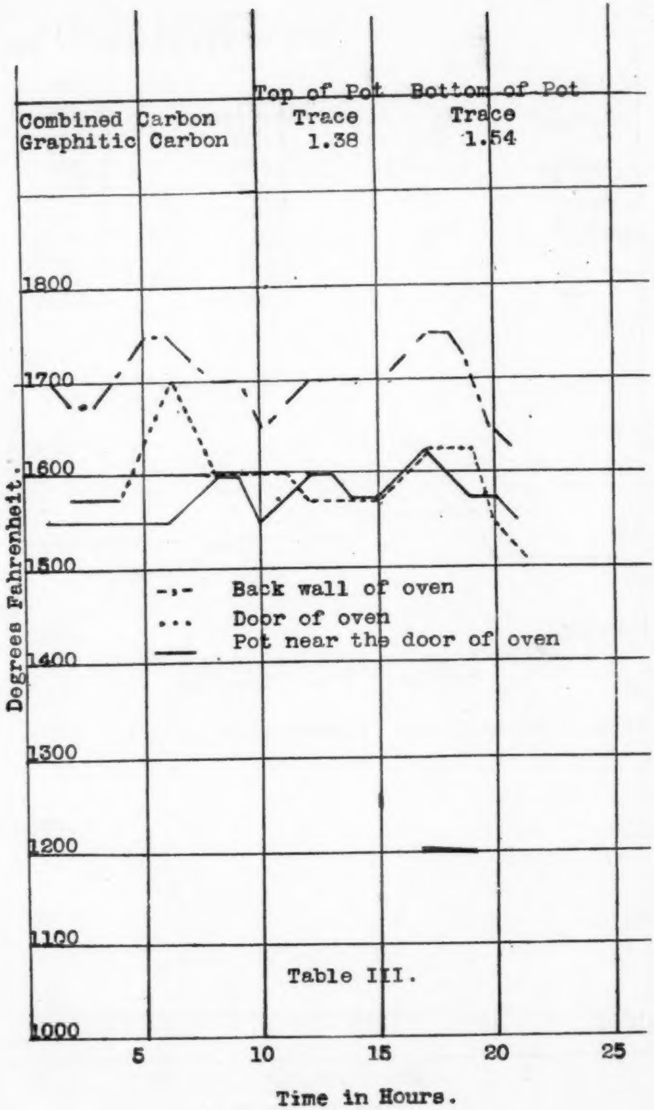


Table II.



Top of Pot
Bottom of Pot
Combined Carbon
Trace
Trace
Graphitic Carbon
1.38
1.54
1800
1700
1600
1500
1400
1300
1200
1100
1000
Degrees Fahrenheit.
-,- Back wall of oven
... Door of oven
— Pot near the door of oven
5
10
15
20
25
Time in Hours.

Table III.

Pot #	Graphitic Carbon Top of Pot	Graphitic Carbon Bottom of Pot
1	1.51	1.65
2	1.78	1.77
3	1.68	1.69
4	1.72	1.88
5	1.86	2.00
6	1.60	1.89
7	1.68	1.81
Av.	1.68	1.81

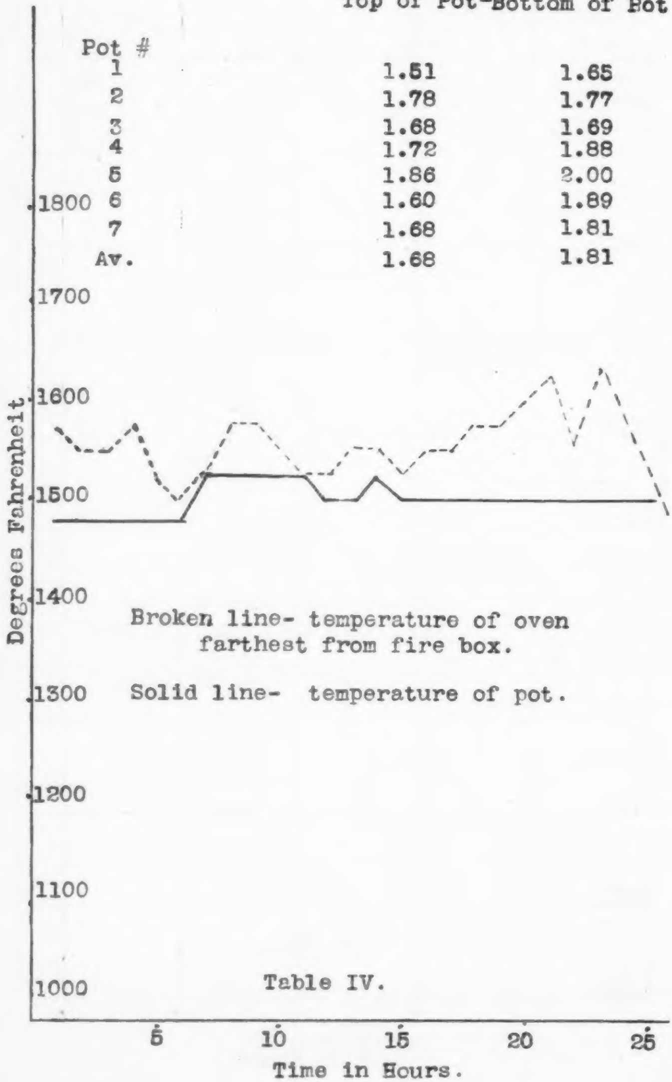


Table IV.

High Sulphur Iron.

	White Iron	1600 Degrees 1st. Anneal.	1575 Degrees 2nd. Anneal.	1600 Degrees 3rd. Anneal.
Si.	.68	.67	.59	.57
S.	.170	.177	.167	.183
P.	.186	.190	.186	.189
Mn.	.24	.21	.24	.27
C.C.	2260	.92	1.00	.40
G.C.		1.26	.88	.65

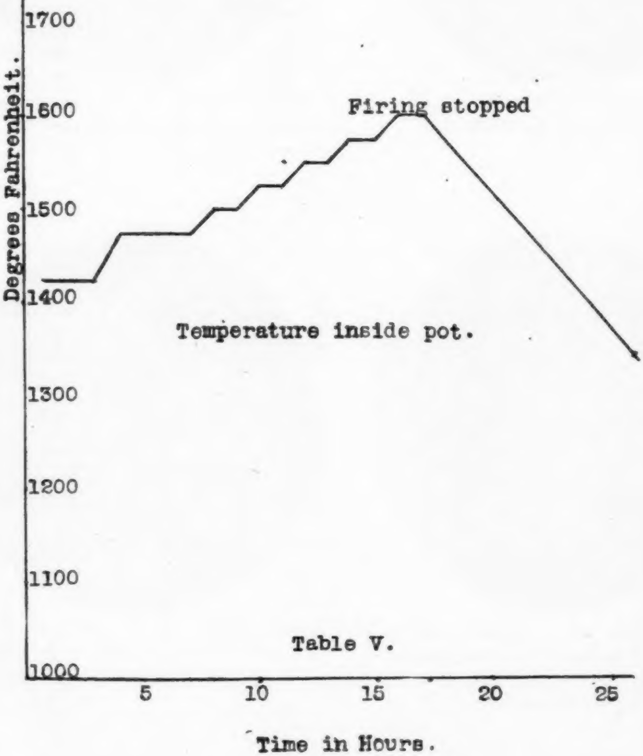


Table V.

Table VI.

Over-Annealed Iron.

	1	2	3	4
Silicon	.52	.60	.60	.53
Sulphur	.062	.063	.059	.069
Phosphorus	.175	.174	.195	.190
Manganese	.31	.32	.24	.23
Comb. C.	Trace	Trace	Trace	Trace
Graph. C.	.84	.49	.48	.03

The Effect of Annealing a ¾-inch Square Bar Three Times.

	1st Anneal.	2nd Anneal.	3rd Anneal.
Silicon	.68	.70	.78
Sulphur	.052	.052	.052
Phosphorus	.186	.188	.187
Manganese	.28	.30	.27
Comb. C.	Trace	Trace	Trace
Graph. C.	1.97	.73	.25

Table VII.

	Si.	S.	P.	Mn.	C. C.	G. C.	E. L., in lbs. per sq. in.	T. S., in lbs. per sq. in.	R. A.	Elong.
No. 1	.78	.053	.154	.29	Trace	1.89	....	36,086	....	....
No. 2	.65	.048	.165	.34	Trace	.80	28,888	40,666	14.22	7.03
No. 3	.96	.098	.060	.28	.12	.94	78,520	78,520	....	....
No. 4	.74	.056	.154	.40	Trace	.83	37,195	53,283	15.62	21.38
No. 5	.74	.056	.156	.40	.60	.20	....	....	....	....

Bar No. 1.—Table VII is well annealed but weak, due to a heavy draw or shrink extending one-fourth way through the bar.

Bar No. 2.—Over-annealed, but exhibiting good physical qualities.

Bar No. 3.—Under-annealed and high silicon.

Bar No. 4.—Over-annealed. Solid throughout.

Bar No. 5.—Same as No. 4, but reheated to 1,600 degrees after annealing. Carbon reabsorbed in the form if cementite.

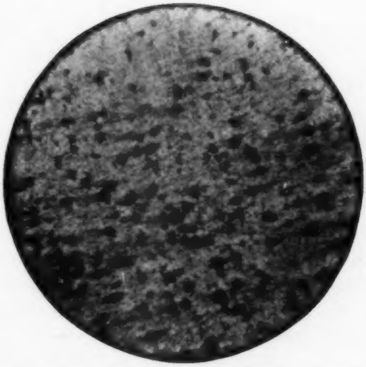


Plate VIII.—Outside of casting showing graphite.

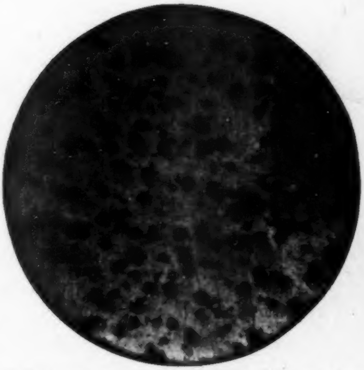


Plate IX.—Center of well-annealed casting showing graphite.

Plate X.—Outside of bar that has been reheated to 1,600 degrees F. after annealing. Showing cementite.

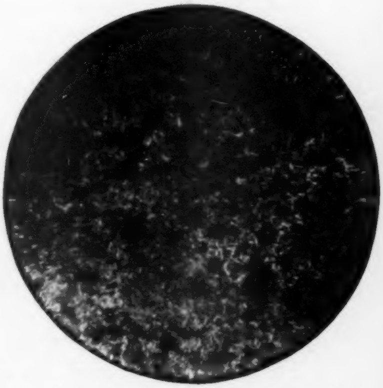


Plate XI.—Center of bar that has been reheated to 1,600 degrees F. after annealing. Showing graphite and cementite.

OPEN HEARTH FURNACES FOR SMALL CASTINGS.

By Walter MacGregor, Indiana Harbor, Ind.

In discussing the subject of open hearth furnaces for the production of steel for small castings, I will confine my remarks to fuel oil furnaces, as operating with this fuel when the furnace is properly designed, the melter will have fewer difficulties to contend with.

If we turn a moment to the steam engineering profession we will see that the engineers in well conducted power plants are giving their greatest attention to the problems of combustion, and in the case of plants already in operation, experimenting to find a grade of fuel best suited to their type of furnaces.

It is a well understood fact among these engineers that the design of a furnace, to get the best efficiency from the fuel, depends entirely upon the nature of the fuel to be burned. Obviously, as we are to deal in high temperatures we are, therefore, to pick out a fuel in heat value and design our furnace to suit the combustion of this fuel.

In order to get the highest heat, our furnace body should be of such proportions that we could burn the necessary amount of fuel in the smallest possible space, and in order to burn a large amount of combustible in a small space a short flame is necessary.

The factors governing the short flame, according to the fuel experts of the United States Navy, are:

First—A pure carbon fuel.

Second—Initial heating of the air which furnishes the oxygen for combustion.

Third—Intimate mixture of the Oxygen with the fuel or diffusion.

Fourth—Large surface of the fuel presented for impact of this oxygen.

The first factor, the nature of the fuel, is settled for us, as we have decided upon fuel oil with a probable analysis as follows:

C.—83.26 per cent. H.—12.41 per cent. S.— .50 per cent. O.— 3.83 per cent.	With a specific gravity at 60 F. of .926.

The heat value of this fuel, according to Du Long's formulæ, would be 19481 B. T. U. S. per pound. From this analysis we can easily compute the quantity of air required for combustion and the products of combustion for any amount of fuel burned.

As a representative size of the small open hearth furnace, we will choose a five-ton furnace as an example, and discuss the conditions that will determine the proper furnace proportions. We are to melt and reduce five tons of metal, and from the time of charging the heat till the time of charging the following heat we will assume as four hours, and as the oil consumed varies so much in different furnaces, we will assume as an average fuel consumption, forty-eight gallons of oil per ton of steel melted in this time, or one gallon per minute.

Considering twelve pounds of air required for burning one pound of carbon, and thirty-four and seventy-eight hundredths pounds of air required for burning one pound of hydrogen, we have from the analysis of the fuel:

9.9912	lbs. of air required to burn the total Carbon in fuel.
4.2161	" " " " " " " Hydrogen in fuel.
14.2073	
.16	Correction of amount for Oxygen in fuel.
14.0473	lbs. air required for complete combustion of 1 lb. of liquid fuel.

With fuel oil of 7.72 lbs. per gallon we have 14.047 x 7.72=108.37 lbs. air required per gallon of oil.

With air at 13.14 cu. ft. per lb. we have 108.37 x 13.14=1424.11 cu. ft. air required to burn one gallon of fuel oil.

Hence, to burn one gallon we must admit theoretically 1,424 cubic feet of air per minute into the furnace. To this we must add the amount of air required in reducing the carbon and silicon in the metal.

Ten thousand pounds charge, of which 12½ per cent. is pig iron of about 2½ per cent. carbon and the rest steel scrap and billets of about .30 per cent. carbon, all to be reduced to about .18

carbon at the time of tapping. From this we get the total carbon contents of the bath as 56.5 pounds, to be reduced to 18 pounds of carbon, or $56.5 - 18 = 38.5$ pounds of carbon to be burned out in about two hours of reducing the charge, and, as before, 157.6 cubic feet of air are required to burn 1 pound of carbon, and we have $157.6 \times 38.5 = 6{,}070$ cubic feet of air required in two hours, or 50 cubic feet per minute. All of this passes off with the products of combustion. In the same way we can determine the amount of air required in eliminating the silicon, which will run about 42 cubic feet per minute. A certain amount of oxygen is also taken up by the manganese, but this is so small as to be neglected.

With the total theoretical amount of air required, $1{,}424 + 50 + 42 = 1{,}512$ cubic feet per minute, we are in a position to determine the proper furnace proportions with due regard to the second circumstance in producing the short flame: "initial heating of the air."

The volume of air is figured at a temperature of 72 degrees F., which will be about the temperature of air entering our valve. The increase in volume of air at different points along its travel due to its increase in temperature must be the governing factor in designing the ports, flue openings, etc., and as the volume of this air increases in a direct ratio to the absolute temperature, it follows that the volume occupied at any point may be computed when the temperature at that point is known.

In case of the air valve, due to the reversing feature of the furnace, this should be figured rather to accommodate the products of combustion than the entering air, as these are at a higher temperature, and will, therefore, require a greater area of flue.

The temperature of the valve is a vital point in the problem of design, for any heat beyond this point toward the stack is lost as far as the furnace is directly concerned, and can only be used in the field of economizers. In determining the size of the valve we will first have to determine the velocity of the products of combustion through the valve due to the draft of the stack, and this in consequence gives as our starting point, the design of the stack, which we would naturally consider as our finishing point.

A number of eminent authorities on chimney design have

chosen 600 degrees F., as the most economical stack temperature, and Rankine has spent considerable time in trying to prove it in his work on "Steam Engines." I have never seen an open hearth stack with that low temperature, and will, therefore, base my calculation on a temperature of 1,000 degrees F., as being more nearly uniform with current practice. In my experience with small furnaces, I find that the most satisfactory stack draft to be maintained is about one inch of water. This is a function of the height of the stack and the difference in temperature inside and outside the stack. With this difference in temperature and a draft of one inch of water we would get a stack 110 feet high, and hence we will assume this as the minimum height to be desired. The velocity of gas due to the pressure head corresponding to this height of stack and temperature, allowing a 25 per cent. friction factor, is a little less than fifteen feet per second, which is recommended by a number of authorities as good practice.

We have based our calculation, so far, on the theoretical amount of air required for combustion, but will design our stack and flues, as in the case of power plant design, for an excess capacity of one hundred per cent., which would be 3,000 cubic feet of gas per minute, or fifty cubic feet per second. This divided by the velocity of fifteen feet per second would give a sectional area of stack of 3 1/3 feet, or a trifle over 2 feet diameter, and we will assume 27 inches diameter of stack as best suited to this furnace, and plenty large enough to permit of any crowding of the furnace. This then will also be the size of the valve and flues leading to the valve from the checker chambers.

The second factor governing the short flames, "the initial heating of the air," spoken of before, is introduced by means of the reversing feature of the furnace through the checker chambers, and these chambers should be so designed as to slow up the travel of the products of combustion, in order that they may give up the major part of their heat to the checker brick, or that part of the heat which is not required to produce the stack draft. The cubical contents of these chambers should not be less than 75 cubic feet per ton of steel melted per heat, and preferably in the neghborhood of 100 cubic feet per ton. These chambers should be located behind the furnace and not immediately under

the furnace. This point is quite as important in small furnaces as in large ones, as they operate at a higher temperature and we should get the benefit of a good circulation of outside air under the hearth of the furnace. These chambers should be long and narrow or deep, in oil burning furnaces, giving a very long travel to the products of combustion, before they reach the valve, as on account of the highly volatile nature of the fuel and the slowness with which many of the hydrocarbons mix with oxygen, a great deal of the fuel will be out in the stack before it has undergone complete combustion.

The methods of gas analysis, as applied to steam boiler practice, will show some very interesting relations in this regard. In a five-ton furnace which I have been operating, a flue gas analysis will show the following:

	CO	CO	O
At the rear of the checker chambers 24 ft. back of the center line of furnace	6.4%	3.1%	.2%
In the air valve 9 ft. further back....	8.8%	.3%	8.0%
In the stack 16 ft. further back......	9.4%	.3%	9. %

With a decrease in temperature between the first and last point from 1,750° F. in the rear of the chambers to 930° F. in the stack.

In case all the fuel were burned before it reached the stack the sum of the oxygen components of the flue gas would be 21 per cent., as there is 21 per cent. by volume of oxygen in all the air admitted to the furnace, the volume of the carbon element being so small as to be considered zero, but as a matter of fact the sum of the oxygen components at the valve is only 17.1 per cent., and even out of the stack it is only 18.7 per cent., which shows that there is some form of hydrocarbon gas occupying the other 4 per cent. which is getting past the valve unburned and being wasted out in the stack. This, I think, shows very conclusively the necessity of having long chambers and flues in oil burning furnaces to insure complete combustion of the gaseous fuel before reaching the reversing valve.

These figures are based on atomizing the fuel with compressed air instead of with steam, as with steam the hydrocarbons are slower in taking up oxygen, and a gas analysis at the valve will show a higher percentage of hydrocarbon gas unburned

at the valve and a corresponding increase in stack temperature. A sample of gas at the base of the stack when steam was used for atomizing purposes showed the following analysis: CO_2, 7.5 per cent.; CO, .4 per cent., and oxygen, 9.5 per cent., or a total of 17.4 per cent. of oxygen components out in the stack which is 5½ per cent. less than shown at the base of the same stack with air, and therefore, a less perfect combustion.

The third condition governing the short flame, "intimate mixture of oxygen with the fuel or diffusion," bears directly on the size and arrangements of the air ports and the furnace body. The size of the ports depends upon the size of the reversing valve, or vice versa, and the relation between the two is in a direct ratio to the absolute temperature at the two points, these temperatures being 1,490 degrees F. at the valve, and 2,800 degrees F. at the ports, or in a ratio of 1 to 2. The ports, therefore, should have an area of twice the area of the reversing valve. We will, therefore, have a total port area at one end of the furnace of about seven feet. These ports should be carried out the full width of the furnace to prevent any short circuit of air through the furnace body, as the travel of gas through the furnace body should have the same velocity at all points to get the proper diffusion. These air ports should come well up above the hole in the monkey wall through which the oil burner enters the furnace, so that the air must come down on top of the flame rather than underneath it. This is a very important factor in designing a hot working furnace.

The space to be allowed for hearth in small furnaces should not be under ten square feet per ton of charge and then, too, the shape should approach more nearly a square than the oblong shapes in general use, as this tends to give a better effect of the radiation of the walls and roof, and by widening the furnace we lessen the cutting action of the flame on the side walls and keep down the repair bills.

As to the length of the furnace body, this should be governed by the length of the oil flame, for the hottest part of the flame should be about the center of the furnace. It has been my experience that I have not been able to get a flame that was intense enough to melt down a charge of metal any less than about eight feet from the tip of the burner to the hottest part of the

flame, and as the tip of the burner should stick clear through the monkey wall, which will extend 9 inches beyond the ports of the furnace at least, we will get as a minimum furnace length, twice the length of the flame as mentioned above, plus twice the width of the ports, plus twice the thickness of the end walls, plus twice the 9-inch extension of the monkey wall beyond the ports, or a total of about 22 feet, as the minimum length of the outside of the furnace body.

The fourth circumstance governing the short flame, "large surface of fuel presented for impact of oxygen," is a matter of oil burners and atomizing agents, and has furnished inspiration to thousands of inventors—all to very little purpose. The matter of atomizing this fuel oil is one of overcoming the surface tension of the oil and breaking it up into very fine particles, so that it will present greater surface for contact with the oxygen, and the two methods in use, superheated steam and compressed air, give a mechanical efficiency so small that you can barely find it at all.

There is a great deal of discussion at the present time on the needless waste of using compressed air for atomizing purposes when superheated steam will answer, but in the small casting business one of the main difficulties is getting the metal hot enough to run the thin sections in the molds, and since by its very nature, compressed air, while atomizing the oil, furnishes at the same time oxygen for combustion, and that too very intimately mixed with the oil, it is quite evident that by using air we would get quicker combustion, a shorter flame and a somewhat hotter furnace.

In conclusion, I will say that in operating a furnace designed along these lines it will not be a difficult matter to get out six five-ton heats in 24 hours, and still have the metal hot enough to pour many castings weighing a fraction of a pound each. With a five-ton heat it is not uncommon to pour as high as 175 molds consuming about 50 minutes in pouring. The metal must, therefore, be extremely hot at the time of tapping the heat.

ON THE SELECTION AND USE OF PYROMETERS.

By S. H. Stupakoff, Pittsburgh, Pa.

Pyrometry has by no means arrived at a point where it is at a standstill. There are constantly new developments, new designs and new achievements to be recorded, all of which have the tendency to make the application of this useful science accessible to every-day shop practice.

Nearly all reliable pyrometers that have been brought out up to the present date have been devised and designed by scientists. To them it is entirely sufficient if an apparatus fills the want of a laboratory for scientific research. Its useful application in practice concerns them but little. That lies not within their domain. The practical man who appreciates the economic value of an innovation usually grasps at it with the sole object of making it a money-maker. The natural outcome is that such instruments are usually presented to us in either the identical form as originally devised, or they are reconstructed and remodeled with little regard to the fundamental principles and requirements involved. Both methods are sadly at fault. The market is flooded with a large variety of instruments belonging to either one of these two classes. That they are more or less readily sold can be seen by their wide distribution among our manufacturing establishments. Yet, it cannot be denied that half of them are unsuitable for the practical worker, owing to their scientific refinements and delicacy of construction. The remaining half are wanting in various other directions. Their principal fault lies in their lack of reliability and constancy. This trouble arises mostly from the fact that too much is claimed for them, and, based thereon, they are in most instances injudiciously applied. Their scope of usefulness lies within well defined narrow limits, and the majority of these instruments can be successfully used to good advantage for many purposes—provided their upper safe limit is not being passed.

That the correct application of a reliable pyrometer in manufacturing process insures superior results in the quality

of products and in their economic production has been repeatedly proven by previous achievements. Many mysteries have been made clear and many perplexing problems have been satisfactorily solved under their guide in the heat treatment of a large number of materials in the majority of metallurgical and chemical processes. And the end is not yet in view. New problems are daily presented to us which need solution and there are daily more exacting requirements specified that must be fulfilled in order to dispose of our products and to meet competition on the market.

Why is it then that in many instances pyrometers are used quite successfully, while in others they have proven a dire failure? Does the fault rest solely with the manufacturer of the instrument, or with the salesman, or is it with the user? Part of the answer has been given in the foregoing. Let us consider *the salesman.* Who would blame him if he succeeds in selling what he has? It is his business to place his goods, whether they be good or bad, whether it is on their merit or on the strength of his arguments, on the good impression he makes, or upon his insistence. We have no good reason to kick with anyone but ourselves if a smart agent succeeds in selling us his goods whether they be of a superior or inferior class, and whether they be useful to us or absolutely useless. If you should know of an agent who succeeds in disposing of a snow shovel to a summer boarder, or a lawn mower to a water rat, or one who is able to accomplish similar marvels of salesmanship, you would earn my everlasting gratitude for bringing him in touch with me. He is the very man I have been looking for for years. Should we blame him, if he is efficient in his vocation, truthful in talking up the merits of his goods and faithful to his employer? No, never! He is not at fault.

Then, let us make the acquaintance of the buyer.

We must distinguish between two classes, namely, the professional *purchasing agent* and the manager of a works. The purchasing agent is specially trained to buy all kinds of materials pertaining to his particular class of manufacture. Only in exceptionally large institutions has he, among his assistants, one or more specialists who are conversant with specific branches. To them is left the selection and ordering of certain classes of

goods that enter into the operating of the business. When definite grades or makes of articles are specified by the superintendent of the works it remains with the purchasing agent to procure them within a set time and on the best terms. His province and his duty is to buy wisely and cheaply. This quality can only be acquired by long experience and by familiarizing oneself with a large number of small details. The purchasing agent, moreover, is incessantly approached by an army of salesmen who present their goods in the most glowing terms. On this account it becomes a most difficult matter to discriminate among different makes from description only, which cannot be given otherwise than in a partial spirit. Therefore, it is not surprising that in consequence of such conditions such are most likely to receive the preference that quote the lowest prices and offer the best terms. This does, by no means, preclude that thereby the business has been materially benefited or best served. Nevertheless, it must be admitted that the purchasing agent has in this way performed his duty in the most conscientious manner.

The manufacturer, the manager or the superintendent of a works, who has attained commercial standing, reputation or prominence through his foresight, judgment, personal ability and capacity of successfully handling men, emergencies and business problems, as a rule, reserves for himself the sole right to select his employees, his raw materials and his appliances. He is often aided therein by able assistants who command a special knowledge of details in their particular branches based on past practical experience. They seldom make the mistake of recommending an inferior article, especially when they are required to show results. They are more or less acquainted with the details of construction of apparatus, the manner of handling their scope and limitations, the accuracy and intrinsic usefulness. And this, it would seem, are paramount requirements for the proper selection of all scientific apparatus, among which heat measuring instruments occupy the foremost rank in many industrial establishments. It is now universally conceded that their judicial application forms an all important factor in connection with the successful course and termination of most metallurgical and chemical processes. While chemists and metal-

lurgical engineers, who are usually in charge of the various heat treatment processes in our factories, have a thorough knowledge of the destructive action that most materials suffer in their chemical and physical nature, when exposed to more or less high temperatures, there are many practical workmen—the actual *users* of pyrometers—to whom this may have never occurred. Among these, it seems, therefore, quite appropriate to institute an educational campaign.

When we heat a piece of iron or steel above red heat (that is about 1,000° F.) a noticeable layer of oxide of iron will form on its surface, which increases in depth or thickness with the length of time of exposure, with the degree of temperature and with the excess of oxygen contained in the heated atmosphere that surrounds it. More than that, under the same conditions, and at the same time quite a remarkable change in the crystalline structure of the material is taking place, which quite naturally involves no less remarkable modifications in its physical qualities. This being universally known, though perhaps few may have given these points the serious consideration which they deserve, it should not be surprising to hear that iron and steel, and for that matter other base metals or their alloys are not the most desirable substances for prolonged exposure to heat in an oxidizing atmosphere.

These conditions prevail in most ovens and furnaces, and yet, we generally select iron or steel tubes as the most suitable protection for pyrometers that are used in medium high temperatures. The principal reason is, they are cheap, and when destroyed can be replaced at small cost. If the pyrometer fire end or fire rod itself consists in part of iron, extra precaution should be taken under the more severe conditions by enclosing it in an additional outer iron protection tube with closed end. In this manner it is possible to quite materially prolong the life of its active portion.

Hardening, annealing and carbonizing processes in the iron and steel industries are always attended by temperatures exceeding 1,300° F., and they are quite frequently pushed beyond 1,750° F. The higher the temperature, the more detrimental it is for the material. Ordinary machinery steel will burn at about 1,850° F. Hardening of tool steel is accomplished by quenching

it at a temperature above the critical point, which in carbon steels lies mostly below 1,350° F. High speed steels are heated for hardening between 2,200 and 2,300° F. The annealing of steel can be done satisfactorily between 1,400 and 1,450° F. Carbonizing, which forms part of the case hardening process, between 1,650 and 1,750° F., annealing of malleable furnace iron between 1,550 and 1,600° F. Malleable iron melted in the cupola requires about 1,650° F.

These figures would indicate that while our base metal thermo-electric pryometers may be quite serviceable for intermittent tests of short duration, we should use at least for their protection other materials than iron and steel when they are exposed for prolonged periods to such deteriorating temperatures. In fact, it cannot be reasonably expected that anyone of them should last longer than a similar mass of the identical material from which they have been constructed, when submitted to the same condition. Over-heating not only changes the grain or the texture, but also the physical properties of most metals. There are other obvious reasons why the constancy of pyrometers of this group cannot be relied upon when certain well defined points are exceeded that lie even within the lower range of our temperature scale. They embrace critical ranges wherein changes take place of the molecular structure of the material that are accompanied by absorptions or developments of heat, by expansion or contraction and by gradually increasing permanent changes in their electrical qualities. This has especial reference to all elements belonging to the iron group of metals. The well-known cooling curve of pure iron by Prof. Roberts-Austen will back up this statement.

For all that, base metal pyrometers should not be entirely condemned. They possess certain practical advantages which are not met with in the higher grades of instruments. It is true, they cease to be instruments of precision as soon as they have been over-exposed to temperatures that lie beyond the lowest transformation point of either one of the metals or alloys that comprise their elements. This gradually increasing change refers primarily to their original calibration. A permanent set, or lag, or change that has taken place can be traced and determined without much difficulty with the aid of a reliable

testing set, consisting of a standardized Le Chatelier thermocouple, a sensitive precision millivoltmeter and a suitable electric furnace. This will be found entirely sufficient for the best shop practice, and it ensures a high degree of accuracy, if properly manipulated. The potentiometer method must be resorted to for refined scientific calibration. Serious changes in base metal thermo-couples, and among these again, especially those constructed of metals belonging to the iron group, only take place when they have been exposed to temperatures exceeding their transition points. The principal one, A_c in iron, lies between 1,300 and 1,400° F.

Leaving all this aside, for which due allowance can and should be made, we have in the base metal pyrometer a strong, serviceable instrument which can be used to good advantage for a large number of metallurgical processes that are conducted at medium high temperatures.

We may go even further than that by asserting that base metal thermo-couples are unexcelled if used within their specific field of well-defined limits. The trouble encountered with them is that their usefulness is nearly always over-estimated. They are over-rated by the salesman and over-exposed by the user. Both try to stretch matters, and both overdo it. This is bad practice! A dimension, a weight or a scale always represents an unalterable quantity. We can no more deceive ourselves to stop hunger by tightening the waist band, than falsify a length by stretching our measure or increasing a weight by coaxing a balance.

Yet, it is quite feasible to make use of a fifty foot tape line to measure fifty-five feet or more by making two or more steps of the operation of measurement. In a similar manner it is quite possible to make use of a base metal pyrometer for the determination of temperatures that lie considerably beyond its crucial point. To give an example—without entering into a detailed explanation, which would lead too far—it may be mentioned that by inserting into a furnace a suitable refractory tube with closed end and thick walls, which may measure one, two, three or more inches, as the case may require, and making use of this as a protective receptacle for our pyrometer, the temperature within the furnace can be at least approximated.

Of course, under such conditions it could not be reasonably expected to obtain infallible information as to the exact degree of temperature within, nor of fine shades of fluctuations, but for a rough estimation it may answer for a number of purposes.

There are few who have not frequently made similar rough approximation in their daily pursuits which entirely served the purpose. Excessive refinements of measurements are often out of place. Thus, it is always sufficient to measure the depth of a hole for a fence post with a rough stick; to step off a piece of ground for a cabbage patch, or to estimate mileage traveled on a railroad by counting the number of rails. Again, if we were to roughly assert some details, say pieces of wires of platinum, silver, nickel and aluminum—when used to handling such materials—we would simply weigh them in our hands, or try their stiffness by bending between our fingers, or be guided by their color and metallic lustre.

You say that these examples, though true, are far fetched. Well, let me quote something that is part of your very business. Is it not customary to judge of the proper pouring temperatures of metals by their color and limpidity? Is not pig iron, to some extent, yet graded by fracture, and coke judged by sound and lustre? Who, in his daily routine, would go to the trouble of using refined methods or mathematical instruments for the rough estimation of any one of these or similar quantities and qualities?

Of course, it is fully appreciated that these methods cannot serve all purposes. We would not buy a valuable piece of city property without carefully establishing its location and extent by exacting transit methods. We would not expect to make train connections without being guided by a reliable time-piece, or locate the meridian with anything inferior to a good sextant. We would not buy or sell precious metals by guessing, but determine their weight with an accurate balance, and we have been taught that pig iron should be bought only on valuation based upon chemical analysis.

We encounter almost identical conditions among the different methods and processes that are followed in the heat treatment of our various articles of manufacture. In some isolated cases it actually suffices the present stages of our knowledge in the arts to roughly approximate temperatures. But steadily advanc-

ing achievements in all branches should convince us that to obtain the best results, it becomes more and more essential to accurately follow set rules for careful observation and close regulation of all necessary steps during the progress of our thermal processes. Such requirements would prescribe that our temperature measurements must be made with more or less—and often with exceedingly great—accuracy. Then it becomes necessary to make a most careful selection of the instruments that shall serve as our guides, and the utmost precautions must be observed in their application. And this suggests that it is commendable to procure the advice of a specialist in such matters.

It has been referred to above that the deterioration of some of the vital parts of pyrometers that are exposed to higher temperatures than those they can withstand without injury may be detrimental to their lasting qualities and to the constancy of their calibration. If such instruments are to be used to give close readings of actual conditions they must be checked at frequent intervals against a correctly calibrated test couple. This soon becomes a tiresome task, and it is always a much time-consuming and, therefore, a costly proceeding. The first cost of the pyrometer under such conditions plays but a small item. If, for other reasons, it is not absolutely objectionable, it would be far better to use in such a case one of the higher class of rare metal pyrometers. For some purposes, such as melting processes, etc., there is almost nothing but these to be had that would answer. Many users of base metal thermo-electric pyrometers would be surprised to learn how large the error becomes with prolonged use in some makes of these instruments. Unless the extent of such errors are known and corresponding corrections are made in their readings, they had better be entirely abandoned. It practically would amount to the same thing as being compelled to accurately determine distances or any other dimensions with a measure of length—a tape line, for instance —which is made of a yielding material that is subject to permanent set.

It is well known that the upper limit of rare metal (platinum, platinum-rhodium) pyrometers is about 3,000° F. This fits them for following up the temperature during the melting processes of all metals—excepting those belonging to the platinum group—

provided they are properly applied and protected. Up to within recent date, either alloys of iridium and of rhodium with platinum were used for the construction of their elements. The former combination has been abandoned—with the exception of a few inferior makes—after it had been established that iridium, even after it had been alloyed with platinum, would volatilize at temperatures exceeding 1,500° F. This would naturally involve a drop in the electro-motive force of a thermo-couple and, correspondingly therewith, a gradual change in its temperature indications.

The platinum, platinum-rhodium thermo-electric couple is known as the Le Chatelier pyrometer, when used in connection with a suitable D'Arsonval galvanometer. This combination, which was the result of a long series of carefully executed, tedious and costly tests, was never patented by its originator, and if it had, the patent would have expired many years ago. The only satisfaction that the celebrated savant derived from this useful invention was that this pyrometer is universally known by his name. At the time of this writing it has been in use perhaps thirty-five years or more, and it has been accepted and adopted ever since by all physicists throughout the world as our only standard for the measurement of high temperatures. It would seem a waste of time to repeat here a detailed description of this apparatus; it has been so frequently described, and the few whom it may have escaped will have little difficulty to find a full account of it elsewhere. The writer published a little pamphlet on this subject during November, 1905, and those interested may have a copy of it for the asking as long as the supply lasts.

But since the present paper has for part of its object to discuss the proper selection of pyrometers, it may be appropriate to mention that Le Chatelier pyrometers, or to be more exact, "platinum, platinum-rhodium thermo-couples," are brought on the market by several manufacturing platinum refiners. And it should be remembered the different makes not only show considerable variations from each other, but even among themselves. This is a feature of the greatest importance that should never be lost sight of.

It is quite natural that the user would wish to replace one

thermo-couple by another one of the same class without further troubling himself. Variations in the calibration of our standards would produce conditions not unlike those as existed in Germany some forty years ago in measures of length and weight, when each of its petty states had a standard of its own. Thermo-couples will wear out, as does everything else; they must be occasionally renewed. Also, when more than one pyrometer is used in the same establishment, it will be found almost absolutely necessary that either one of them can be substituted for the other. It would cause an endless amount of confusion if one is not an exact duplicate of another. In fact, it would necessitate changing the calibration of the indicating or recording galvanometer that is used in connection therewith. Annoying, time consuming and costly as this is, it is not nearly as bad as when more than one thermo-couple is used in the same plant, all of which are supposed to be read with the same galvanometer. If in such a case we have thermo-couples differing in electro-motive force we may as well throw up our hands. There are no other remedies but to get a special indicating instrument for each particular lot of thermo-couples that happen to have indentical calibration, or get others to take their place.

Such conditions have come under the personal observation of the writer, and though they may be considered among the most valuable experience that has been gathered in through many years of practice, you may rest assured that it was dearly paid for. The user may profit by this costly acquired knowledge when buying rare metal thermo-couples, if he can get it in black on white, that when called for after any number of years they will be replaced by others that shall show in no instance a variation in electro-motive force exceeding, say, ½ or ¾ of one per cent. Considering that the electro-motive force of such a couple represents about 17 millivolts at 3,000° F., the possible error accruing at this rate would remain below 15 or resp. 25° F. at the upper limit of the scale, which for all practical purposes is perfectly admissible without going to the trouble to have all instruments recalibrated.

What in this respect is true of rare metal thermo-couples is no less important for base metal pyrometers. And more so, especially because these are not made with nearly the care that is

exercised in the selection of the materials for the former. It is no rare occurrence to find different lots of base metal thermocouples of the same make vary from each other 10 per cent. and more. Adding to this the errors which may be (and as a rule are) caused by poor connections in the leads, low resistance galvanometers and occasional over-exposure of the couples, the users invite conditions which will often produce results that lead toward the opposite direction than that which it is aimed at. This is not conducive to spreading faith in pyrometers, especially because there are but few of the users who would give such matters the proper attention they deserve. Nevertheless, all this can be rectified with little trouble, if one would but take the ordinary precaution of checking an instrument with a reliable testing set, such as has been referred to above.

THE CENTRIFUGAL COMPRESSOR FOR CUPOLA USE.

By Richard H. Rice, West Lynn, Mass.

The problem of providing proper supply of air for the operation of a foundry cupola is in many respects analogous to the problem of providing proper supply of air to a blast furnace. The blast furnace requires much larger volumes of air, and under more arduous conditions, since the operation of the blast furnace is continuous for many months; whereas, the operation of the foundry cupola is discontinuous, it being in operation only through a few hours each day. Therefore, the foundry cupola is not subject to the great variations in conditions of operation, which occur in blast furnaces, due to this long continuous operation, and also the foundry cupola conditions are improved owing to the differences between the physical characteristics of the charge of pig iron, as compared to the physical characteristics of the ores, which are charged in the blast furnace. Therefore, we find that the blast conditions in the cupola are much more uniform than they are in the blast furnace, and the requirements for properly operating a cupola under all conditions can be met by apparatus which produces practically a constant pressure; whereas, in the blast furnace apparatus, constant volume is the prime requisite and apparatus must be provided capable of working under a considerable range of pressures in order to meet the fluctuating conditions met with in the operation of the furnace.

Centrifugal compressors of the same general type as that which I wish to bring to your attention, consisting of one or more rotating impellers in series, taking air at atmospheric pressure and compressing it to pressures required for the service of the blast furnace, that is to say, 12 to 15 pounds, average pressure, and 25 to 30 pounds, maximum, with provision for passing air at a constant rate, have been used on blast furnaces for some five or six years, in England and on the Continent, but no machines were put on a blast furnace in this country, of the type mentioned, previous to March, 1910, when the first machine in this country was put in service at the Oxford Furnace of the

Empire Steel & Iron Company, Oxford Furnace, N. J. This apparatus has been found to be absolutely adapted for the requirements of blast furnace blowing, and a number of machines are under construction for similar situations, of various capacity, based on the good results obtained by these first machines. Similarly, on cupola work in the iron foundry, it has been found that this type of apparatus is perfectly adapted for use in connection with a furnace adapted for melting iron and the same reasons which make it peculiarly adapted for blast furnace service, also afford many points of excellence in the operation of the cupola.

One of the important points in connection with this apparatus, which is of benefit in cupola work, is the extreme steadiness of the blast. You are, of course, aware that the steady melting of iron and the steady descent of the charge from the cupola are dependent on the maintenance of uniform conditions of air pressure, because the charge in the cupola is, to some extent, supported by the pressure of the blast, and if this pressure varies, the charge is likely to descend in a more or less irregular manner, and such irregular descent of the charge causes an irregular, unsatisfactory working of the cupola. Therefore, the uniform, steady blast produced by the centrifugal compressor, produces more uniform, steady conditions of melting.

Another point which is of importance in this connection, is the high efficiency of the centrifugal compressor, and the maintained efficiency after long periods of service. This efficiency is due to improvements made in the design of the apparatus, as compared with the centrifugal fans which have often been used for this purpose, and which are, as compared with this apparatus, very wasteful in power absorbed. The improvements in this apparatus, as compared with centrifugal fans, reside in the methods of changing the velocity, impressed on the air by the movements of the impeller, into pressure, by the gradual slowing down of the air, and the fundamental principle which is responsible for this improvement in efficiency is that the slowing down of the air must be done in a perfectly definite manner and without the production of any eddies.

Having obtained this high efficiency, it is essential to maintain it, and the apparatus in question is peculiarly suited for this,

since there are no rubbing parts whatever inside the compressor and the efficiency does not depend on the maintenance of such rubbing parts in their original condition. Since the impeller is the only moving part of the compressor, and since this impeller rotates with ample clearance on all sides, it always compresses air with the same efficiency. The parts which slow the air down as above indicated are stationary and are not subject to wear, so that no matter how long the machine may be in operation, assuming that this operation is unattended by accident, or lack of lubrication of the bearings, which would cause vibration and difficulty, the efficiency of the machine will remain absolutely unchanged.

Now, as regards the actual efficiencies obtained, the best way to discuss this question is to compare it with other forms of blowing apparatus for cupolas, and I do not propose in this paper to enter into technical or scientific discussions of the question of efficiency, because strictly scientific comparison of the apparatus used for blowing cupolas is difficult. This is owing to the fact that one of the principal means for blowing the cupola is the positive pressure blower, and the positive pressure blower since it discharges its air in the form of a pulsation, or wave of air, which causes the pressure in the discharge pipe to vary to a considerable extent, is very difficult to test for volume. The usual method of determining the volume discharged by a positive pressure blower is to calculate the displacement of the impellers per revolution, and from this by determination of the speed, estimate the quantity of air which is discharged. This quantity of air is called "displacement air." Such experiments as we have been able to make indicate that the displacement air may be 15 or 20 per cent. in excess of the actual quantity delivered by the blower.

The means by which we are able to test the volume of air discharged by apparatus of this nature, do not give a true average if the quantities measured are fluctuating in amount, as they are when the air is discharged from a reciprocating compressor or a positive pressure blower, and, therefore, the means of actually testing the air from such apparatus are not sufficiently accurate to give a thoroughly scientific test. Approximations can be made, and these approximations are always in favor of the positive pressure or reciprocating machine, since the quantities of air

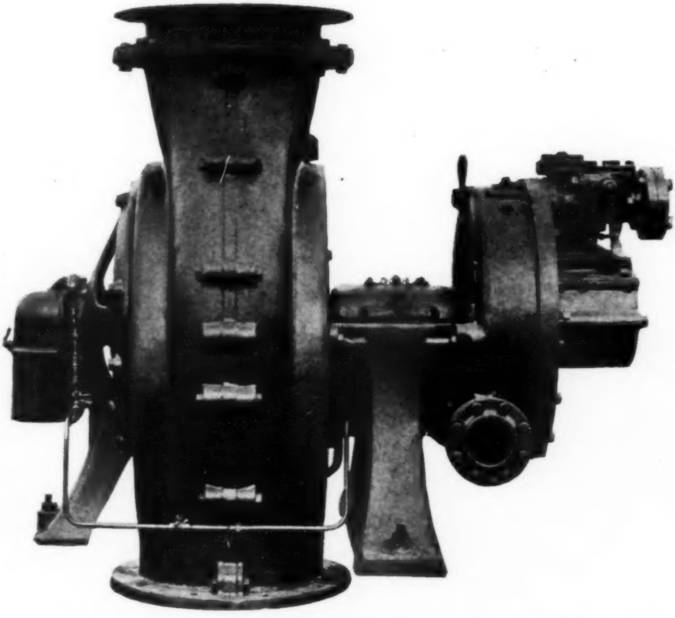
given by these methods are always too great. However, if precautions are taken to measure the pressure and volume at the end of a long pipe of large capacity so that the fluctuations in flow and pressure are smoothed down to a considerable extent, fairly accurate results can be obtained.

It is also legitimate to operate blowers of different types on a furnace under exactly the same conditions to determine the power input of these blowers and the output of the furnace in tons of iron melted, and this method forms an excellent means of comparing such apparatus. Such comparisons have been made with the fan blower and with the positive pressure blower in competition with the centrifugal compressor blower which I am describing, and it has been found that the power input required to melt down the same quantity of iron with the centrifugal compressor, is less than that of any of the other forms. The positive pressure blower comes nearer to the compressor than the fan blower by a considerable extent, but there is still a reasonable margin of difference between the positive pressure blower and the centrifugal compressor blower in favor of the latter.

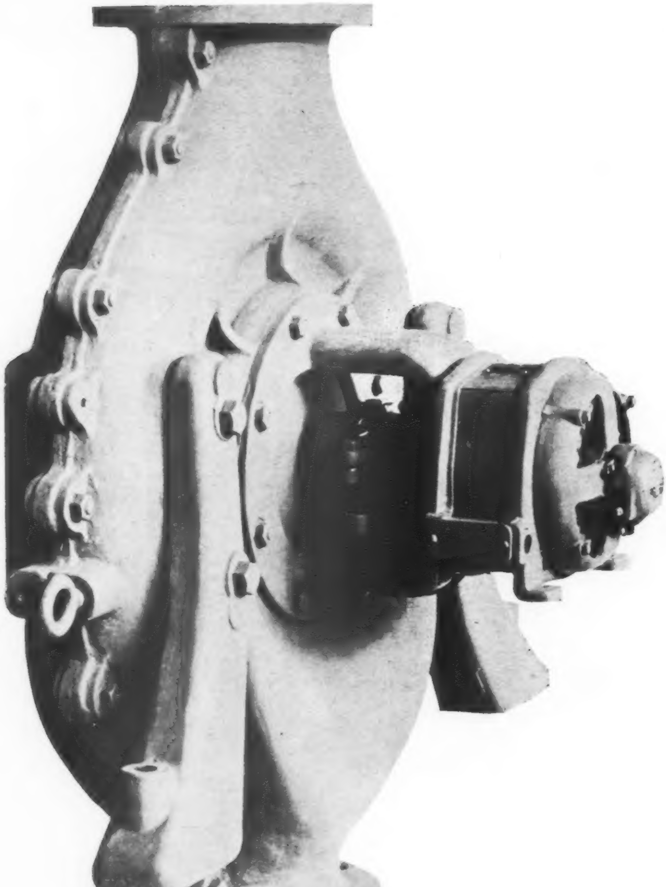
We, therefore, have the following points which are of importance as determining the superiority of the centrifugal compressor for blowing cupolas:

1. High efficiency.
2. Maintained efficiency.
3. Uniform, steady blast producing steady, uniform operation of the furnace.

Other advantages exist of somewhat less importance, such as much greater floor space occupied by positive pressure blowers and their greater weight, requiring stronger floors to support them, or stronger foundations, as the case may be; the larger number of bearings in positive pressure machines; the necessity of spending considerable sums for maintenance of such machines, due to the wear of the parts and necessity of eliminating such wear; while the centrifugal compressor has two bearings, automatically lubricated, which do not ever come in metallic contact, and, therefore, do not wear; and the absence of any necessity of repairs in the compressor end of the machine requires a nominal amount of attention and nominal cost for maintenance.



208442. TYPE T-700-.72-3500-FORM O CENTRIFUGAL AIR COMPRESSOR COUPLED TO 50 H.P. CURTIS STEAM TURBINE, FORM A5, RUNNING AT 3500 R. P. M., FOR 110 LBS. BOILER PRESSURE.



258248. TYPE T-1-800-1-3450 CENTRIFUGAL COMPRESSOR DRIVEN BY TYPE KT 2-5 H.P. 3600 R. P. M. INDUCTION MOTOR.
INDEX E-318.64—E-312.4.

The apparatus consists of a shaft supported in two bearings, carrying on one end an impeller of the most rugged and substantial construction, and on the other, between the two bearings, the rotor of an electric motor, or turbine wheel of a steam turbine. In the case of motor drive, motor may be actuated by alternating current or direct current. In the case of a steam turbine, the steam may be at any pressure from 100 pounds upward, and may be discharged into the atmosphere, or be run condensing. The high speed motors used are built along lines which are the result of extended experience and they are reliable and satisfactory. The steam turbines are of great simplicity and of high efficiency, and since compressor and turbine are of best efficiency when running at high speed, the combination of the two is efficient and desirable.

The principal difficulty which has been met with in the installation of such compressors in connection with iron foundry practice has been that the requirements for air have been overestimated by the purchaser, and in many cases the apparatus which we have installed was found to be too large. This is due to the fact that all the data which have been compiled on the requirements of air on cupola have been based on figures of displacement made in the manner above indicated. Tests were made under my direction on a cupola in actual service melting iron in an efficient fashion, and it has been found that the quantity of air required for melting iron in the cupola was considerably less than that usually supposed. For instance, the well established rule for the selection of positive pressure blowers for iron foundry cupolas is based on allowance of 30,000 cubic feet displacement for one ton of iron. This rule has been reinforced by computations of the number of cubic feet of air required for burning one pound of carbon to CO_2, and the further fact which has been established experimentally, that one pound of coke is sufficient to melt ten pounds of iron. The computation which is the basis of the statement that 150 cubic feet of air are required to one pound of carbon burned to CO_2, is based on the supposition that coke is pure carbon, which is not the case. Coke contains only about 90 per cent. carbon, and is not all burned to CO_2. A great deal is burned to CO, requiring only about 90 per cent. of the air which is required if all the coke was burned to CO_2. The

result of these qualifications is that only 80 per cent. of the theoretical amount of air above computed is actually needed. This 80 per cent. efficiency of the air necessary is also about the difference between the actual air discharged by a positive pressure blower and the computed, or displacement air. Therefore, the rule is correct for positive pressure blowers and is not correct for computations of the actual quantity of air needed. The tests above mentioned confirm these figures. They showed that one pound of coke would melt from 10 to 12 pounds of iron. As high as 12 pounds was obtained in some cases. The variation apparently is due to the difference in temperature of the iron tapped off. The conclusion is that the ratio of one to ten commonly used is reasonably correct.

The tests involved accurate measurements of the quantity of air passing into the cupola by means of pitot tubes, and the most accurate methods of measuring quantity, and these tests showed that 24,000 cubic feet of air was sufficient to melt a ton of iron, or 400 cubic feet of air per minute would be required for each ton per hour. We know that this figure agrees exactly with the 30,000 cubic feet of displacement air usually assumed in positive pressure blower work and a volumetric efficiency of 80 per cent. Enough tests have been made on the foundry cupolas to warrant the statement that these figures are correct and should be used in proportioning blowers for cupolas which are to be made on the centrifugal compressor design.

Tests made by the above method on apparatus delivering a steady blast without pulsations, that is on fan blowers or centrifugal compressors, are extremely accurate, and the accuracy of such tests and quantities may be determined with a possible error of not over one to two per cent.

Test has been made by piping up a positive pressure blower and centrifugal compressor to the same furnace in such wise that either one of these machines could be operated at will, and it has been found that the quantity of iron produced with the same input of current is greater in the case of the centrifugal compressor than in the case of the positive pressure blower.

THE MANUFACTURE OF SMALL STEEL CASTINGS BY THE CONVERTER PROCESS.

By Bradley Stoughton, New York City.

This subject has been already discussed so thoroughly before this Association, that not many points remain to be covered. One matter, however, which it seems to me has not been sufficiently exploited is that of silicon in the pig iron which varies all the way from 1.50 per cent. going into the cupola (equivalent to say 1.25 per cent. in the melted pig) up to sometimes as much as 2.50 per cent. No doubt a greater proportion of silicon is required when only a few heats per day are made, as well as when the blowing is slow and when the metal is retained a long time in the converter; as, for example, if it is poured out into hand ladles, requiring 30 minutes or so per heat. In our opinion, hotter steel and less loss may be obtained by rapid working and lower silicon—say not more than 1.75 per cent. to 1.50 per cent. into the cupola. Silicon has a treble effect in causing waste of metal:

1. It is the slag producer of the process. Every unit of silicon present is oxidized, enters the slag and remains there permanently. In this respect silicon differs from iron, manganese and other elements that are oxidized, all of which may be afterwards partly reduced by the carbon and given back to the metal. Side blow converter slags are composed chiefly of silica and oxide of iron (with a certain amount of manganese, depending upon the manganese in the pig iron used). It will have been noticed by all those accustomed to have these slags analyzed, that every type of practice automatically produces a slag of a certain analysis in iron. Colder blows may increase the amount of iron in the slag, and vice versa, but as a general thing, the iron content of the slag is approximately uniform, and, therefore, the weight of slag will determine the weight of iron lost in it. For example, if a slag normally contains 30 per cent. of iron, and weighs 10 per cent. of the bath, then the amount of iron lost in the slag will be, 30 per cent x 10 per cent.,

equals 3 per cent. of the total metal present. If, on the other hand, a slag weighs 15 per cent. of the bath, and contains 30 per cent. iron, then the corresponding metal loss will be, 30 per cent. x 15 per cent., equals 4½ per cent. The amount of slag produced is an important cause of waste of iron.

2. A second source of loss due to silicon is increasing the length of the blow, and especially the interval before the carbon begins to burn. During this interval there is a large amount of brown smoke formed in the converter, all of which represents loss of iron by oxidation and volatilization. The longer this action continues, the greater will naturally be the iron wasted by this means.

3. Finally, all the silicon introduced with the pig iron is burned up, and this likewise represents a loss of weight.

We are also in favor of rapid working as a cause of hotter steel, lower cost for labor, less loss in skulls, etc. It would seem that every plant should aim to produce at least three blows per hour, and at the rate of not less than 12 blows between 1 P. M. and 4.45 P. M.

A good deal has been said and written about the many failures of converter steel foundries in this country, which have been all too frequent. The converter process has naturally had to bear the blame for these failures, but we think that the causes lie deeper than the process itself. A converter foundry is almost foredoomed to failure if it attempts to compete in an open market with the open hearth process in castings averaging over 100 pounds apiece. The converter cannot hope to make large castings at as low a price as the open hearth furnace. It can make small castings at a cheaper price than the open hearth furnace, and can get a better price for them on account of greater freedom from blow holes, and better appearance and detail. This high price is necessary for the success of a converter foundry, however, because an open hearth foundry will usually underbid the price on small castings for one or both of two reasons:

1. An open hearth foundry with large production, can afford to lose money on a comparatively small amount of castings for the sake of other business.

2. Open hearth foundries frequently do not know how

much their small castings cost them, because they do not segregate the small castings from the large and estimate separately the percentage of defective castings, which is what runs the price up to such a high figure in open hearth practice.

In making a comparatively small tonnage of small sized castings, the percentage of defective castings in this class may be as high as 20 per cent. without this fact becoming evident on the daily or monthly statement, except occasionally by accident.

Another frequent cause of failure of converter foundries is lack of sufficient capital with which to do business on a business basis. The cost of installation of a converter foundry is so small that many companies rush in with small capital. This has happened so frequently that buyers of steel castings are always ready and prepared to take advantage of the opportunity and they soon learn it when a foundry is in difficulties and is ready to accept work at low prices for the sake of quick cash. More often than not the final result is failure and abandonment after a few months' struggle, but unfortunately there are usually enough of these tottering companies in the field to keep the market for small castings in a disorganized condition to the serious detriment of the business. This is not real competition, and in the end will drain the strength of the industry as a whole.

It would seem that both open hearth and converter foundries could serve their own interest best by agreeing to divide the field on a logical basis, each process confining itself to the class of casting which it can make to the best advantage. It seems to be now pretty generally admitted that the converter can make small castings of higher quality, as regards freedom from blow holes, than the open hearth furnace, either acid or basic.

We think also that if open hearth foundries will take the trouble to figure their defective castings in small sizes separate and apart from their general run of castings, they will find the percentage so high that the cost of making them is seen to be greater than if they put up a converter for the purpose or else sublet the work to a converter foundry. On the other hand, a converter foundry cannot make large size castings so as to compete on a fair basis with the open hearth process and attempts to do so can hardly serve the lasting advantage of either manager or stockholders.

THE PERMANENT MOLD.

By Edgar A. Custer, Tacony, Pa.

It is just two years ago that the writer was privileged to bring the question of permanent molds before this Association. Since then the work has gone steadily forward, and much that is new and vital has been learned. There is no doubt but that the idea is prevalent that the use of the permanent mold has even at this time a comparatively limited application, and is confined to what might be termed strictly duplicate work, but as new fields are being explored the tonnage applicable mounts steadily upward until to-day the field is so large as to stagger belief. When it is considered that there are over 2,000,000 tons of gray iron castings made in the United States per annum, all of which can be made in permanent molds, the possibilities of the process are apparent at a glance. Then, again, there is steel and malleable work that offer wonderful fields for investigation and profit. What the future holds depends upon the amount of technical and mechanical skill that is put upon the question. It is a purely mechanical and technical process and depends for its success upon the mechanical ingenuity expended upon the molds, in collaboration with sound technical knowledge of the conditions necessary and the behavior of the metal at high temperature. Once started on the right road, as far as molds and conditions are concerned, it is simply a question of intelligent organization of the working forces to realize the highest economy.

The principles that underlie the successful operation of permanent molds have been exploited so frequently of late that it is probably best to give that feature but little space, and consider in this paper the various foundry conditions that are essential in order that the molds can be economically operated.

In considering the question of using permanent molds in the foundry it should be thoroughly understood that we must approach this question with entirely new ideas, and from a new viewpoint. Molding in sand and molding in permanent molds

are as far apart as the poles. Although we use the same pig in both processes the results show such vast differences that, in order to get a sound basis, they must be considered as not being comparable, except when the question of the cost of castings is to be ascertained. To successfully use permanent molds one must abandon all the preconceived ideas as to the behavior of the molten metal and must forget all the theories and the effects that influence and affect molding in sand. To all intents and purposes the use of permanent molds is a separate and distinct art. The casting it produces is an entirely different metal from the same casting when made in sand, even when made from the same iron. The difference is not chemical, but is purely physical. The permanent mold castings differ from the sand castings not only in their physical structure, but in their characteristics. A soft, open pig high in graphite carbon becomes a close-grained iron, showing no traces of the graphite flakes, but having the same amount of free carbon as existed in the original pig. It is capable of being magnetized and of permanently retaining the magnetism; it can be tempered and hardened precisely the same as a bar of tool steel, and when tempered will make a cutting tool equal to the best non-alloy steel. This latter fact is true irrespective as to whether the original pig was high or low in silicon. There are no spongy spots and the castings are free from shrinkage strains. The castings can be taken from the mold at a bright red heat and plunged into cold water until cold, without showing a sign of cracks. High shrinkage does not begin in a permanent mold casting until a very low heat is reached; 1,200 degrees F. to 1,400 degrees F. being the point at which the casting must be removed to prevent shrinkage cracking the undercut parts.

The basis of the permanent mold system is the fact that molten iron does not chill—using the word chill to express white, hard crystals—until after the iron is set, and that this chilling does not begin until after the iron has shrunk to the bulk it occupied in the molten state. The diagram, Fig. 1, will make this point clear. As we all know, molten iron when poured into a mold first swells until the point at which it begins to set is reached, then the bulk remains at that point for a short space of time while the cooling progresses, and then it shrinks until cold.

The interval between "A," the point at which it sets, and "B," the point at which chilling begins, is long enough to enable the workman to remove the casting from the mold, and in that time it will be sufficiently hard to be handled without fear of distortion or breakage.

Since it has been determined definitely that iron does not chill until some time after it has set, the main object of the process then is to set this iron as quickly as possible, and

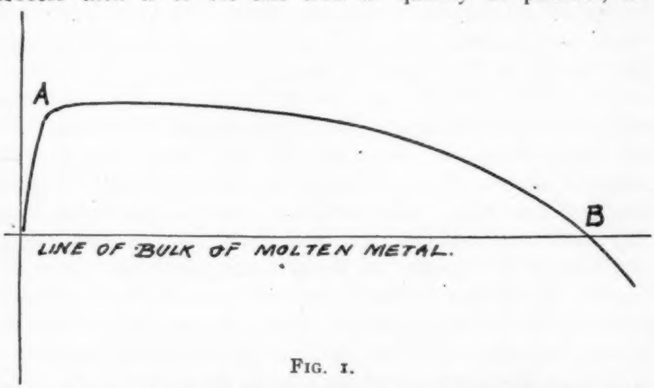


FIG. 1.

when this is done, to instantly remove the casting from the mold. To accomplish instant setting, the molds are made of quite large bulk so that they will have large heat capacity. A further object in making these molds of such large bulk is to prevent any distortion from the heat action.

Since continuous operation of permanent molds entails continuous melting of iron, this brings us to the foundry conditions that are essential to economical production. These conditions may be classified as follows:

Continuous melting.
Selection of proper iron.
Labor saving appliances.
General remarks.

CONTINUOUS MELTING.

It is evident that in order to operate the molds continuously some form of continuous melting must be practiced, and it is also evident that the iron must be melted in comparatively small

quantities per hour—else the tonnage melted per day would require a very large number of molds. Small quantities of iron per hour means small cupolas, so the problem becomes one of melting iron continuously and economically in cupolas that will melt one to five tons per hour. It has been found entirely feasible to operate a cupola 21-inch diam. inside of lining for ten hours a day at an average melting ratio of 8 pounds iron to one pound of fuel and to continue this performance from day to day. It is feasible to run the same cupola for 48 hours. as witnessed by the run noted below, and to have an exceptionally high melting ratio. When we first had occasion to seek information relative to the continuous operation of this small cupola our experience was disastrous, and after several trials with patent fluxes, etc., we solved our problem by using a slight excess of limestone and a change in our fuel charge designed to keep the bed hot. This change consisted of substituting large lump anthracite coal for a portion of the coke on each charge and jumping the weights of the iron charges from 250 to 500 pounds. The larger charge, of course, carried with it a corresponding increase in fuel, which, due to the coal used, retains its life until well below the melting line, thus preserving the life of the bed and keeping the melting zone in the proper place. This change enabled us to keep a continuous stream during a full working day. This was kept up for several weeks until we found by several slight changes in ratios we could drop bottom in the evening with the cupola in such good condition that very little work was required to put it in shape for the next day's run. The general principle being to keep the charges large in the quantity of iron and the draft low in pressure, making sure that the tuyeres were of sufficient area to furnish a surplus of air. When the blast was first turned into the cupola the pressure was kept at fourteen water ounces until the iron began to melt. It was then lowered to six water ounces and kept there throughout the heat. The flux used was limestone, fifteen pounds being charged to each 500 pounds of iron. With this plan no difficulty was experienced in running ten hours each day. As an instance of what can be done in the line of continuous melting the following run made by Edgar A. Custer, Jr., at Tacony Iron Works is quoted:

"The run proper began at 7 A. M. Monday, August 15th, although at 5 A. M. the sand bottom was put in and the customary small quantity of wood lighted. The bed consisted of 140 pounds of coke and 70 pounds of coal. This brought the level about twelve inches above the top tuyeres. The first charge of iron was 300 pounds No. 2 plain pig and 300 pounds stove-plate scrap and foundry gates. The succeeding charges were 35 pounds coke, 15 pounds coal and 500 pounds iron—250 pounds pig and 250 pounds scrap. To this was added 15 pounds limestone. The pressure was obtained from a small rotary fan driven by a motor and regulated by the usual blast gates.

"At 7 A. M. the cupola was tapped out and on the twentieth charge it was found that the iron was too hot for our use. The iron charge was then raised to 600 pounds, the fuel remaining at 50 pounds. At 6 P. M. the night gang came on who were relieved at 7 A. M. August 15th, at which time there had been used 64 charges, totalling 36,500 pounds, or about 1,520 pounds per hour, at a ratio of 10 pounds of iron to one of fuel.

"After 47½ hours continuous running it became necessary to drain the cupola and drop bottom in order to repair the lining. This consumed 7½ hours and the cupola was started at once. The second run was almost identical with the first, except the melting was rather slow and sluggish for an hour—probably due to the repair. This second run ended at 2 P. M. Friday, August 19th, a total of 49½ hours of continuous running, during which 73,000 pounds of iron were melted, with a ratio of eleven pounds of iron to one of fuel.

"As a grand total this cupola was operated for 97 hours out of 103 and melted a total of 144,800 pounds, or about 72 tons at a rate of approximately ¾ ton per hour at a fuel ratio of 11 to one.

"On this run a battery of eight permanent molds was used and these molds were poured at the rate of one round each five minutes, without showing undue heating.

"Since then we have run a cupola 42-inch inside lining for sixty hours at the rate of seven tons per hour, with a melting ratio of ten pounds to one. In this case the iron was much higher in silicon and required more fuel to melt."

Selection of Proper Iron.

The permanent mold is not a cure-all for foundry ills, and the same care must be exercised in selecting the iron for each line of castings, as is the case in any other foundry proposition. The main elements that must be avoided in permanent mold work are manganese and sulphur. High manganese has the effect of making permanent mold castings hard and brittle, in this respect being radically different from its effect in sand castings. High sulphur tends not only to make the castings hard and brittle, but has a decided tendency to form holes in those portions of the castings that will not permit of the employment of risers. The influence of silicon is very slight when its percentage ranges from 2 per cent. to 3 per cent.

The ideal iron for permanent mold work would be as follows:

Silicon	2.25%	
Sulphur	.04%	or under
Manganese	.40%	or under
Phosphorus	.50%	
Total Carbon	4.00%	

Labor Saving Appliances.

Every effort should be directed toward making the work as easy as possible. The iron should be brought to the molds on easy running trolleys and in ladles so balanced as to require the minimum amount of effort to pour. The molds should be so placed as to allow pouring direct from the trolleys, and provision made to protect the men from splashing iron. Conveyors should run beneath the molds to remove the hot castings rapidly from the room. In addition to this each man should be required to do but one operation for each casting made. If there are five distinct operations necessary from the pouring to the closing of the mold, five men should be provided. Under this system, with a battery of ten molds, the time to make a casting is the time necessary for the pourer to fill the mold and move on to the next. With a battery of castings ranging in weight from ten to twenty-five pounds this time is about twenty-five seconds. As an evidence of what can be done with a gang well-trained and equipped with labor-saving devices, I present a record of one of our batteries

where the castings are larger than those usually poured, being principally T's and Y's and averaging twenty-one pounds each. One gang was timed and counted with the following result:

	Castings produced.	Castings lost.
9 to 10 A. M.	123	2
10 to 11 A. M.	119	1
11 A. M. to 12 M..............	146	1

In this work the cores were pulled with air-lifts and the iron was supplied the gang in ladles hung on trolleys. In some cases, where the character of the casting permits, the mold can be designed so as to allow very rapid work. The plow-point mold that is shown in the exhibit is a good example of this point. In this mold 300 castings have been made in two hours. In a mold containing two 2-inch flange unions, over five hundred castings have been made in two hours.

As the use of permanent molds contemplates the employment of unskilled labor, due allowance must be made for the grade of intelligence they possess, and they should be surrounded with every safeguard possible. They should be required to wear substantial foundry shoes and gloves—especially shoes—as the process is carried out on cement floors that tend to scatter carelessly splashed iron. Too much emphasis cannot be laid on subordinating the personal equation by the use of power where possible; every man movement eliminated means a decrease of the probability of bad work. Where but one line of work is made this latter feature becames a necessity.

General Remarks.

The question that invariably crops out when we are talking of iron molds is—"How long do they last?" We have been working on them continuously for five (5) years and can only say—"They are practically indestructible." The only place where the mold disintegrates is in the runners and gates. The matrix of the mold, never in our experience, shows any sign of wear or crumbling. After we have made from seven thousand (7,000) to ten thousand (10,000) castings we generally renew the gates by inserting new blocks. The cost of this repair is generally ten (10) per cent. of the original cost of the mold. We have made twenty-one thousand (21,000) castings in a single mold, each casting weighing ten (10) pounds and the matrix

to-day shows the original tool marks. The life of the mold does not depend so much on the number of castings that are poured into it as upon the number of times it is allowed to become cold. Working a mold continuously, day and night, will quadruple the number of castings that may be made before repairs are required.

Each mold is primarily designed to produce one thousand pounds of castings per day, and in our room containing thirty-seven molds there were produced eighteen (18) tons of good castings in ten (10) hours. The floor space required by these molds is 60 feet long by 26 feet wide, and to produce the same tonnage of the castings in sand a floor space of 450 feet long by 105 feet wide would be required. Also to produce the same tonnage in sand the services of fifty-four (54) expert foundrymen would have been required whose pay would average $3.50 to $4.50 each per day.

In April, 1910, a statement was made that this process was not dependent upon skilled labor and that ordinary laborers could be employed upon it without previous experience and get economical results. In order to test this out, on Friday, April 21st, we hired eighteen men from the streets, sixteen of them could not speak English, and but one of them had ever been in a foundry before. On Friday and Saturday we simply pushed these men around and endeavored to teach them not to be afraid of the molten iron. To the eighteen men we added three of our more experienced workmen, and on Monday these twenty-one men were turned over to an outside concern who then assumed entire charge of this portion of the plant. They took account of the number of castings made, the hours of the men and the costs that entered into the production of these castings. There were thirty-seven molds. The average molding cost alone of these castings when made in sand was six cents each, figured on a piecework basis. The results of this test follow:

		No. hours work.	No. castings made.	Cost per piece.
Mon.	4-25-10	7	896	.023
Tues.	4-26-10	10	1,419	.021
Wed.	4-27-10	10	1,767	.0169
Thurs.	4-28-10	10	1,972	.0152
Fri.	4-29-10	10	2,174	.0138

The cost of these castings when made in sand, for molders' labor alone, was $9.02 per ton. The molding cost the last day of this test was $2.14 per ton. To the molding cost of these castings when made in sand must be added rumbling and cleaning and the cost of sand.

There is one more feature that has never been published and that is the saving in gates that can be accomplished by continuous running. In all cases we find our iron too hot when the cupola is properly run. When this condition arrives the gates are broken from the castings while red hot and are placed in the empty ladles. The iron is then tapped on these gates and the resultant melt is about the right pouring temperature. On the last day of the run above quoted there were made sixteen and one-half tons good castings and there were remaining 125 pounds of gates.

In conclusion, it may be said that the permanent mold is an accomplished fact; and that when the same high type of practical and technical brains shown in our present day foundry improvements is turned toward this newer phase,—the results will be such as to astound the most enthusiastic supporter.

ALLOYS.

By Dr. W. R. Whitney, Schenectady, N. Y.

Secretary's Note:—This admirable paper was presented before the American Brass Founders' Association, and read at the joint meeting of that Society with our own body. It is therefore included in our Transactions. Received through courtesy of the Author and the American Brass Founders' Association.

This is not intended as a paper describing accomplishments, but is aimed at contributing, if possible, to increase the interest of experimenters in new alloys. It is the result of reading Mr. Stevenson's paper on "The Value of the Association to Its Members," and a letter from the Secretary, asking for a contribution to the papers of the American Brass Founders' Association.

I want to call attention to the possibilities in the way of useful discoveries which may well lie more nearly within reach of some of the members than they realize, because of their particular knowledge or possession of special materials. For example, it frequently happens that one manufacturing company produces a new metal or alloy for some particular use, which, owing to lack of general study, may remain the sole use for a long period of time. Probably those who produce the special cerium-lanthanum-iron alloy used in the various types of friction cigar lighters have not been able to study very thoroughly the application of this alloy to other uses. So also, those who use the very modern metals, tantalum, tungsten and molybdenum, have been engrossed with applications to a single field and have hardly been able to look carefully into others. It is often through the interchange of information across the gap between quite remote fields that useful advances are made.

It occurred to me that even an imperfect review of some of the relatively recent metals might not come amiss. Probably few realize the rapidity with which new metals are coming into use, particularly in alloys. There are, in all, approximately fifty metallic elements, though most of our important industries employ but a few of them. Some of these, in the metallic state, have market prices which are not yet controlled by the cost of produc-

tion nor by the infrequency of occurrence, but rather by the lack of development of a utility. Beginning with gold, which we may assume is the one element whose exchange value depends upon its commonness in nature plus its cost of production; and passing over iron, copper, lead and zinc, whose values may be said to be well fixed by occurrence and costs of production, we soon reach other metals, for which a new demand might well greatly reduce the cost. Among these are many whose ores occur in abundance. In the case of this type of element the interest attached to research work is doubly great.

It is highly improbable that the cost of copper will ever be greatly changed by the discovery of new uses. This is because the world's supply of the ore is pretty well known, the demands are high and the costs of production of metal from ore have been so studied that further reduction will probably only be of about what I like to call the second order of magnitude. This was not true of the metal aluminum a few years ago, and it is still possible that considerably wider uses and reduction of production-costs may be developed in its future. There is apparently a much wider divergence between the occurrence of aluminum in nature and its price in metallic state than in the case of copper. In case of aluminum, only selected and purified ores are used at present, while other compounds of it occur everywhere in nature. On the other hand, in the case of copper, ores containing even less than two per cent. of copper are worked for the metal. Aluminum may thus still be considered in the transition state, a state long ago passed by copper and iron and not reached by some of the metals considered below. We have all been witnesses of the interesting advance of aluminum. From 1860-74 its properties were becoming generally known. The inefficient process by which it was then reduced from its ores made it impossible to sell the metal below $10 per pound. Advance was then made so that in the 80's the price was about $5. There was not a great demand for it at this price. In the year 1907 something like 26,000,000 pounds of this metal were made in America alone. The price is now about 20 cents per pound.

The element *calcium*, which a few years ago was listed only as museum specimens and at several dollars per gram, was sold in 1908 at $1.50 per pound, and could certainly be sold for a small

part of this price if a greater use could be found for the metal. Its ores are everywhere and it is only awaiting commercial use. It slowly decomposes water, giving hydrogen, and it differs from the alkali metals in producing such a feeble alkaline solution that it is generally harmless. It ought to serve as a good deoxidizer and should be a very cheap metal. It is not fair to relegate it to a list of useless metals. History of the metallic arts points to there being no such list.

Thallium is an element quite similar to lead, but probably possessing some property which will some day warrant its exploitation. It is softer and heavier, and could be obtained in quantity if a demand were created.

The elements *chromium, molybdenum, tungsten* and *tantalum,* the three latter now obtainable in wire-form, are tempting elements to study in mixtures with others. Who knows the useful properties of a chromium bronze, for example?

Tellurium has long been an apparently useless metal and any market price is fictitious, as there is but little isolated in metallic state. It is not necessary that a great use, such as a substitute for zinc in brass, should be found for it. Our industries are so great that if a pound of tellurium added to the ton of aluminum was of benefit to the latter, the production of the necessary tellurium would be a real industry.

Consider *cobalt* a moment. The world's rate of supply of ore has been greatly augmented. It may take time to actually realize a greatly reduced cost of metallic cobalt, but we ought, notwithstanding, to realize it when uses have been developed. Our natural impulse in such a case is to try direct substitution of one metal for another in some well developed use. Cobalt, for example, might replace nickel in most uses when the cost fell below that of nickel, but this is a second order use. A first order use would be the supplying of a want which no metal previously supplied, or supplied distinctly less perfectly.

In this connection, an interesting alloy of cobalt and chromium has just been described by Elwood Haynes in the October number of the *Journal of Industrial and Chemical Engineering,* and it is altogether probable that technical use will soon be made of it.

Many tons of metals are annually consumed as resistance wire for electrical purposes. At one time iron was the element most used. German silver replaced it in some cases where a lower temperature coefficient was needed and the increased cost was permissible. Now there are a dozen or more special alloys for this particular electrical use. The new ones have far outclassed the old in most of those properties for which the electrical engineer uses them. In such alloys nickel, chromium, manganese and others are now used by the ton.

Silicon, which in 1900 was a curiosity and sold for 40 cents per gram, is now a necessary component of special iron alloys and of high grade transformer iron, and the world uses thousands of tons of the alloy annually. Silicon is now sold at about 5 cents per pound. The use of this metal in other alloys is still quite limited. In the case of iron, is greatly decreases hysteresis loss and increases electrical resistance.

Boron, still a quite expensive material in metallic state, is coming into commercial use in assisting in the making of solid copper castings of high electrical conductivity.

Vanadium seems to be a young wonder working metal. Its use has increased very rapidly in the past few years, but the quantities consumed are not known to us. As several companies are producing the iron alloy, it is safe to assume that it is being sold by the ton. The price for the metal in the alloy is not far from $5 per pound.

Cadmium is a beautiful metal in many respects, and it is certainly awaiting use. It is whiter and less crystalline than zinc, and doubtless the high price of nearly a dollar a pound keeps practical workers from trying it in their experiments. It should be produced as cheaply as aluminum, if there were a good demand for it.

Titanium is an element long the subject to criminal negligence. It is a high-melting ductile white metal, which at present is only separable from its ores at high cost. It exists in many cheap ores widely distributed in nature. It is now apparently coming into use in steel manufacture, particularly for railroad rails, and for this purpose it is fortunately unnecessary to isolate the pure titanium from its ores, an iron titanium alloy being

produced directly. What will happen when the pure element has been tried in special fields can only be surmised. The optimist sees great chances. The pessimist feels himself busy living with the optimist.

If one omits the common alloys, brass, bronze, solder, etc., and considers only possible alloys of two metals, and still confines himself to twenty of the common metals, like vanadium, manganese, chromium, boron, etc., he is interested at once to recognize that there must be one hundred and ninety different pairs or binary alloys. When, in addition, the effect of varying proportions in these alloys is considered, it becomes evident that the field of alloy-research is truly a large one. Many of the alloys apparently still unstudied are those which melt at extremely high temperatures.

The brass founder who knows the upper limiting temperature of his melting furnaces may at once point out that this temperature is fixed both by the life of crucibles and by the particular coke or oil heating schemes with which he is familiar. If he thought that a molybdenum bronze of 80 per cent. molybdenum would have useful properties compared with all other alloys, he might at once conclude that he must give up his alloy because of the difficulty of melting it. If it were not for the advances in our available temperatures, there would seem to be little more than amusement in considering alloys high in tantalum, in chromium, in titanium, in molybdenum, in silicon, in uranium, in vanadium and a number of other high melting metals, but hand in hand with the discoveries leading to isolation of such metals go also discoveries of alumino-thermics, oxyacetylene and oxyhydrogen temperatures and electric furnace processes. The time is always ripe for the study of new alloys with new tensile strengths, elasticities, colors and wearing powers. The automobile and the aeroplane have forced the aluminum and iron alloys to make rapid strides, and it is natural that we should want to inventory our possibilities. The physical chemist has started along the way of a systematic co-ordination of certain properties of binary, and in a few cases tertiary alloys. He has shown how to plot a few freezing points of two-metal and three-metal mixtures and to construct therefrom curves showing not only all

possible melting points of those metals, but what may be expected in the way of segregation and structure and such effects as caused by annealing or quenching.

He has found that there is a solubility of metals in one another which varies just about as the solubility of substances in water varies. Metals may be melted together and well mixed, but the quality and permanency of the mixture is determined by just such solubility laws as control ordinary solutions. We know that in some cases well-mixed melted metals will separate into two layers if allowed to remain even a few moments in molten condition at low temperatures. Such a pair are zinc and lead. They act like a mixture of water and ether. The two separated layers contain both metals, no matter what the temperature, but the quantitative composition depends on the temperature.

The other extreme of metal solubility is found in such a case as zinc-cadmium, which acts much like a mixture of alcohol and water, the two components going into solution in all proportions and remaining in solution at all temperatures. Having seen this analogy between the facts of solubility of substances in water, it is natural to search among the metal mixtures for all the peculiar kinds of solution observed in aqueous solutions. Two such classes interest us at once. They are those corresponding to aqueous solubilities, where temperature widely influences the quantities dissolved, and those in which the solvent (as water) combines with the dissolved substance more intimately than by simple solutions, as by chemical combination. In the case of zinc and lead we have one of the metal alloys of limited solubility. If these two metals are well mixed in liquid state, they separate into layers—one, the zinc, carrying a few per cent. dissolved lead, floats on an alloy made up of lead carrying a few per cent. of dissolved zinc. In general, the quantity of the one metal dissolved and held in solution by the other, depends on the temperature, and the higher the temperature the greater the solubility. Between 900 and 1,000 degrees C. they are apparently completely soluble. It follows from this that when a dissolved pair of metals is cooled slowly, one of them may separate on cooling, if the limiting solubility is reached, and the extent of effective separation may depend on the rate of cooling.

Our second case, that of chemical combination between the metals, is made most evident by the form of the freezing point curve of the possible alloys. A compound of two metals which is stable at a temperature above the melting point of one or both of the metals, shows very clearly on the melting point curve and acts towards each of the elements just as a new, or third element. Its melting point cannot be predicted from any knowledge of the component metals. It may even melt higher than either of the components. Such cases are seen in alloys of aluminum-antimony, in lead-tellurium, etc.

Man first used the metals as he found them; then, as he reduced them from the ores, and finally, when specific requirements became more and more exacting, he not only brought into use previously unused metals, but also greatly modified the old familiar ones. For a harder iron he used steel, a carbon alloy; for a harder *steel,* or one capable of cutting iron more readily, he added tungsten, nickel, chromium and other metals. For permanent magnets molybdenum was added; for high electrical resistance nickel, chromium, etc., were added; for low electrical hysteresis, silicon and aluminum were added; for toughness in springs a little vanadium was used, and for wearing qualities titanium is now introduced. These are only a few of the successful alloying experiments with iron. They will probably be repeated with other metals, such as copper, zinc and aluminum, where the cost of the base metal is not high.

On the other hand, the study of those metals which have not yet advanced to a stage where first order cost reduction is impossible, is equally interesting. Consider again the element chromium. What do we know about it? Is it a workable metal? Can it be hammered or cast? Is it permanent in the air? Is there a considerable possible ore supply? Has the cost of obtaining the metal been reduced to what seems a reasonable rate? etc., etc. As it is unlikely that such an element will suggest itself for use by men as did copper and iron, it is probable that its properties must first be determined and made known. As a metal, it is only about fifteen years old. It is made in the metallic state by reduction of the oxide by metallic aluminum and also by electrolysis of its salt solutions. It cannot yet be produced at a lower cost than that of

the aluminum required, and it now sells at about 80 cents per pound. In the oxide from which it is made, it may be had for less than half this cost, and in alloys with iron, which are made by direct reduction with carbon, it is sold for 29 cents per pound. This gives a rough idea that ultimately by perfection of metallurgical processes, etc., we may possibly obtain the metal much below 80 cents per pound. It withstands heat exceedingly well. When pure, it melts at very high temperature (Ostwald, about 3,000 degrees C.) and it does not scale when heated red hot in air, as copper and iron do. It is for this reason that it is used in resistance alloys for electric heating devices. It has been plated onto metals, and then looks and acts much like nickel-plate. Doubtless its use will quite rapidly increase in special alloys, as it has already come into use in tool steel.

THE EQUIPMENT OF AIR FURNACES USING OIL AS FUEL

By W. N. Best, New York City.

Many attempts to burn liquid fuel in air furnaces have failed because of the operator not being able to melt the full charge or to get the metal as hot as when burning coal. Often the charge was oxidized to such extent that what metal did become molten was practically worthless. Usually a number of burners, each giving a round flame, have been placed in the side wall of the furnace, and as the number of burners was increased, the equipment became more and more intricate. Something had to take the blame for the wasted time, material and effort, so oil was condemned as being unworthy of further consideration.

Let us for a moment consider the ultimate analysis of the average gas coal used in air furnaces and fuel oil.

This coal contains:

Carbon	70.0 to 75.0
Hydrogen	4.5 to 6.0
Oxygen	10.0 to 18.0
Nitrogen	1.0 to 2.0
Sulphur	0.5 to 1.5

The calorific value being from 13,500 to 15,300 B. T. U. per lb. Analysis of residuum or fuel oil:

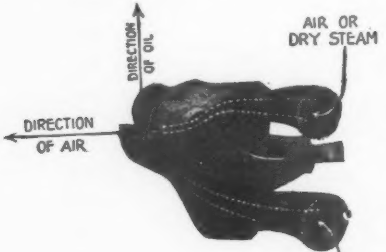
Carbon	84.35
Hydrogen	11.33
Oxygen	2.82
Nitrogen	.60
Sulphur	.90
Gravity from	26 to 28 B.
Weight per gallon	7.3 lbs.

Calorific value ranges from 18,350 to 19,342 B. T. U. per lb.

From this data the natural conclusion is that oil, having

a much higher calorific value than coal, ought to be able to melt the metal in a much shorter period of time than coal. Not only that, but it should also be able to bring the metal to the temperature required for even the smallest castings. It can do both if properly applied, and furthermore, the quality of the metal is improved, for by chemical analysis and numerous tests, it has been found that the castings contain no more sulphur than the metal did when charged into the furnace, and the tensile strength is consequently greater than of metal melted by coal fire. As the melter has the furnace under perfect control, the heats can be taken off much quicker than while burning coal, and the temperature of the charge while being tapped can be maintained without varying more than 25 degrees Fahr. until all the charge has been run from the furnace. The operation of skimming is materially decreased—this is a very noticeable improvement which is especially appreciated by the melter. The high calorific value of oil also enables the melter to estimate within a few minutes as to the exact time when the charge will be ready to tap, which is a great contrast to conditions while burning coal, especially in rainy weather when climatic conditions are unfavorable and the stack draft is materially affected.

The change from coal to oil is a very simple matter. In the original fire-box I construct a combustion chamber of such form and proportions that the air necessary for perfect combustion can unite with the atomized fuel before it reaches the furnace, which prevents oxidization of the charge. Also this chamber causes the heat to be deflected upon the entire surface of the bath. In the end



of this combustion chamber I place a hydro-carbon burner of peculiar form, which makes a fan-shape blaze, filling the entire chamber with flame. This burner exteriorly atomizes any gravity of liquid fuel which will flow through a ½-inch pipe, such as fuel oil, crude oil and tar. Its construction is such that it can-

not carbonize, and there are no parts to wear away or get out of order. A very small quantity of compressed air is used through the burner to atomize the fuel and distribute the heat, while the balance of the air necessary for perfect combustion is supplied at from 3 to 6 ounces pressure through a volume air nozzle.

The furnace is charged in the usual manner. The burner is started by opening the air valve, holding a piece of burning waste (which has been well saturated with kerosene) by means of a pair of pick-up tongs under the burner and then turning on the oil. This burner is very simple to operate. In fact, it is so very simple that one must see it in operation in order to appreciate that you can get as intense heat with it in a few minutes as from burning coal for several hours.

The reduction in the time required to get the charge ready for tapping is not the only point wherein oil is more economical than coal. There is no handling of fuel and ashes, consequently the services of the fireman and coal passers are dispensed with. There is great saving in floor space for the oil tank is placed underground and the former coal bins used for other purposes. The fire brick lining of the furnace lasts 20 per cent. longer than with coal. Poor castings or imperfect ones caused by the metal being cool or sluggish, are obviated entirely, for with liquid fuel, the question is not—how hot can you make the metal, but how hot do you wish it. All these items should be taken into consideration when comparing the relative costs of using oil and coal in air furnaces.

Strange to relate the first air furnace which I ever tried to equip stands on the identical spot where the first malleable iron was made in the United States by Seth Boyden. The plant is now known as the Barlow Foundry Co., and is located at 28 Orange St., Newark, N. J. Mr. Barlow, the president of this company, is a very progressive man. He had tried on several previous occasions to burn oil on his air furnace but was not wholly discouraged because of his repeated failures and when a friend suggested that he let the writer equip his furnace, he was willing to give oil another trial. A combustion chamber was built in the original fire-box of his furnace on a Saturday afternoon more than a year and a half ago. On the following Mon-

day the first heat was tapped out in the usual manner and to date oil has never failed or disappointed them. The saving of space because of their not having to store coal, the time and cost of operation, the quantity and quality of their output from this furnace is such that they have no more desire to return to coal again than to exchange their electric lights for tallow candles.

Several months ago Mr. Geo. H. Graham, secretary and treasurer of the Malleable Iron Co., Oriskany, N. Y., visited the Barlow Malleable Iron Works and was so impressed with what he saw there that he has equipped his air furnace. The equipment is likewise a success in every respect.

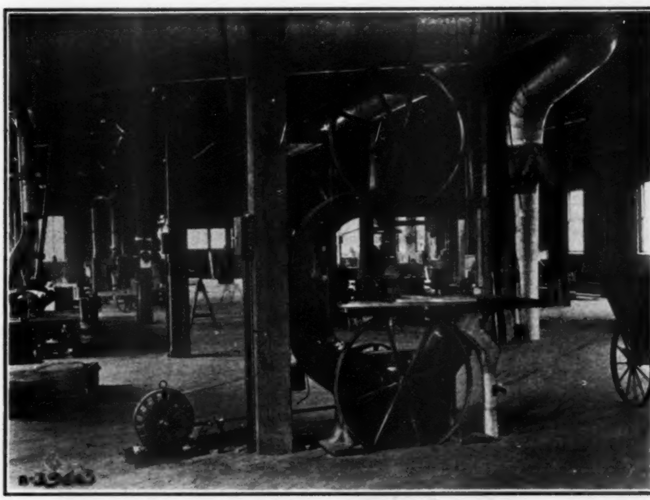
As far as the writer has heard, these are the only two plants in the United States wherein oil has been successfully installed in air furnaces, but what has been done in these plants can be done in others. I believe that eventually all furnaces of this type will be equipped, even in localities where coal is cheap and oil comparatively high, for every progressive manufacturer wants to keep pace with the march of progress. Several malleable iron works are now installing this system.

Many firms have tried to improve the metal made in cupolas by adding steel to the charge, but the castings were not satisfactory, for steel requires more heat than pig iron. By constructing an oil-fired air furnace wherever most convenient in the plant, melting the steel and pig iron in this, they will be thoroughly mixed, and can either be run into castings at once or into pigs to be used in the cupola whenever desired. When metal is melted in a cupola it absorbs the sulphur contained in the coke, but in an oil-fired furnace of proper construction the sulphur contained in the fuel is oxidized in the combustion chamber before it reaches the bath of the furnace.

ELECTRICAL APPLICATIONS IN THE FOUNDRY.

By Brent Wiley, Pittsburgh, Pa.

With the advent of the electric overhead traveling crane, about eighteen years ago, electricity became a governing factor in perfecting foundry methods, and to-day the general and most important advantages offered by electric drive for practically the



MOTOR OPERATED BAND SAW, SHOWING INDIVIDUAL MOTOR DRIVE FOR PATTERN SHOP MACHINERY.

entire machine equipment are well established. However, there are many features of electrical engineering as applied to the foundry which are the objects of continued attention and study on the part of the foundrymen and all others interested in foundry engineering, including the electric manufacturing companies; and it is the object of this paper to review the most important subjects, including the advantages of the system and apparatus best adapted for the various applications, and point out to what extent

MOTOR-OPERATED MACHINES. FINISHING DEPARTMENT UNITED ENGINEERING AND FOUNDRY CO., VANDERGRIFT FOUNDRY.

the question of economies can be effected by the present-day developments of the art of electric drive and general applications of electricity.

The advantages of electric motor drive for machinery used in the foundry may be summed up as follows:

(1) Adaptability of motors to all classes of service, by reason of compact construction, substantial

MACHINE TOOLS EQUIPPED WITH INDIVIDUAL MOTOR DRIVE.

characteristics and flexibility of mechanical and electrical design.

(2) Wide speed range, ease and certainty of control; automatic devices insure the safety of the motor and the driven machine.

(3) Easy and inexpensive distribution of power by electric conductors and the saving of power by direct connection of motor to machine, eliminating line shaft and belting.

(4) Advantages of centralized power.

WESTINGHOUSE AIR BRAKE CO. FOUNDRY, SHOWING CONTINUOUS MOLDING TABLE.

It is quite logical to state that these advantages are well established in the minds of foundrymen, since electric drive has been adopted so universally. It would be well, however, to review these applications in order to recall to mind the exact conditions of operation, and consequent requirements of motor characteristics and characteristics of power supply system best suited from a general engineering standpoint.

IRON FOUNDRY.

Stock Yard.

Overhead traveling crane.
Magnet for handling pig iron and scrap.
Skull cracker for breaking up scrap.

Cupola.

Positive blower or fan type.
Elevator.

Molding Floor.

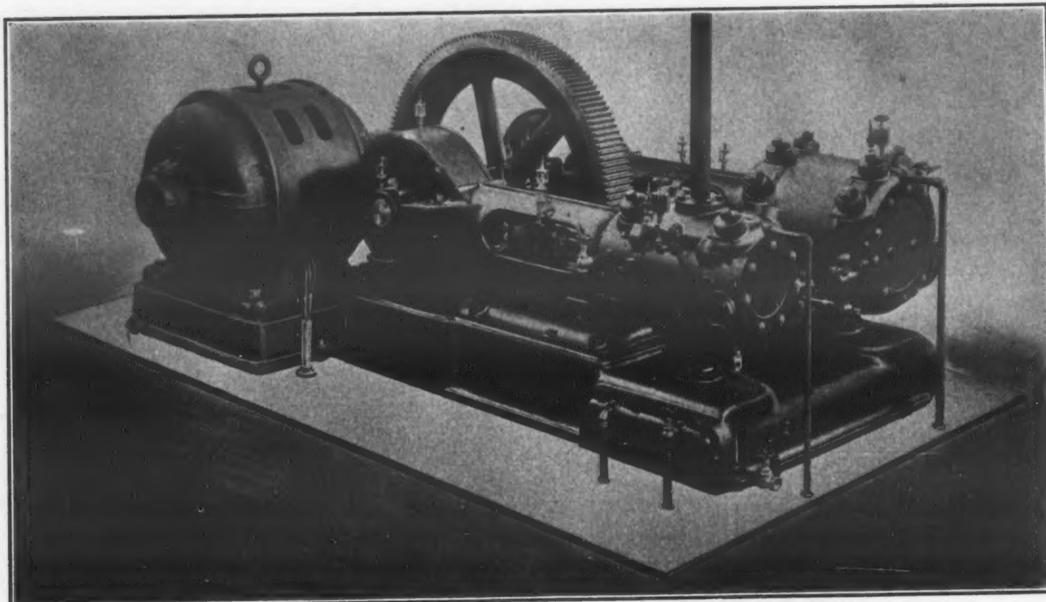
Crane { Overhead traveling. / Jib.
Molding machines.
Core machines.
Sand cutter or mixer.
Sand sifter.
Traveling tables / Sand elevators / Sand conveyors } For special foundries.

Pouring Floor.

Crane { Overhead traveling. / Jib.

Cleaning and Finishing Department.

Crane.
Tumblers.
Grinder.
Lathe.
Shapers.
Drill press.
Planer.



AIR COMPRESSOR OPERATED BY WESTINGHOUSE TYPE "MS" INDUCTION MOTOR.

STEEL FOUNDRY.

Stock Yard.

Overhead traveling crane.
Magnet for handling pig iron and scrap.
Skull cracker hoist.

Furnace Department.

Charging machine.

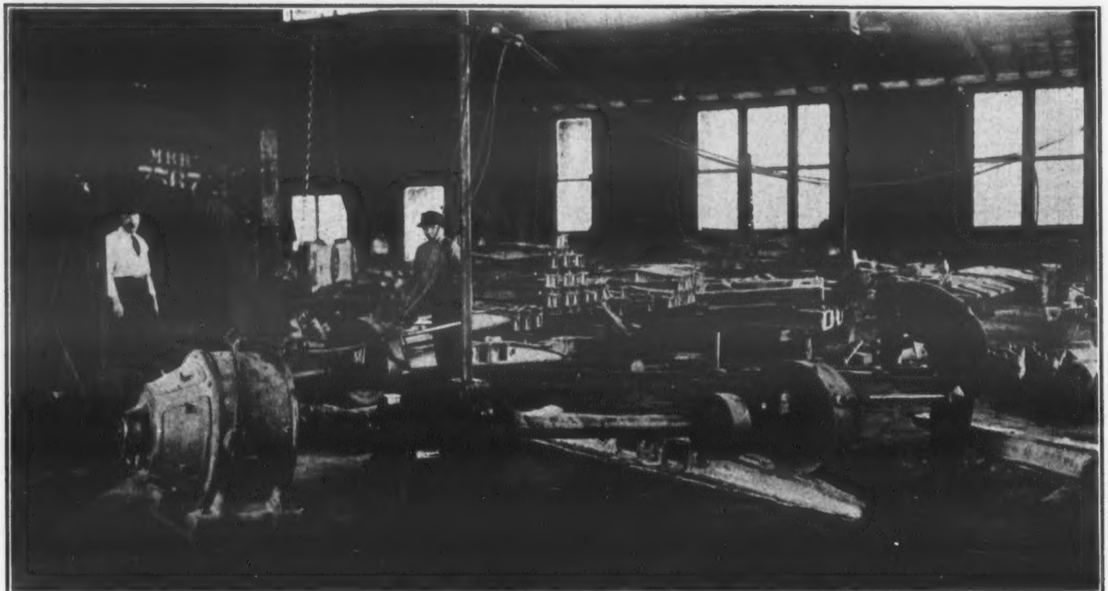
MOTOR OPERATED PLANER, SHOWING INDIVIDUAL MOTOR DRIVE FOR PATTERN SHOP MACHINERY.

Molding Floor.

Crane { Overhead traveling. / Jib.
Sand mill.
Molding machine.

Pouring Floor.

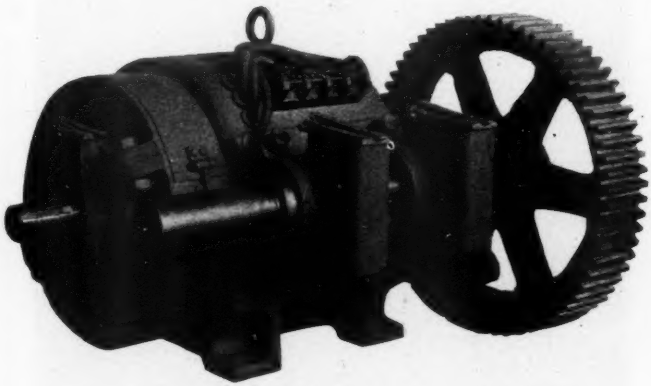
Crane { Overhead traveling. / Jib.



HASSEL, DIRECT DRIVEN, SWINGING GRINDER, OPERATED BY WESTINGHOUSE TOTALLY ENCLOSED TYPE "S" DIRECT CURRENT MOTOR.

Cleaning and Finishing Department.

Crane.
Cold saw.
Grinder.
Lathe.
Planer.
Shaper.
Drill press.



WESTINGHOUSE, TYPE "K," DIRECT CURRENT CRANE MOTOR.

APPLICATION COMMON TO ALL FOUNDRIES.

Air compressor.
Fans for ventilating and heating.
Pumps.
Coal- and ash-handling machinery.
Pattern shop machinery.
Machine shop machinery.

It is not the intention to give engineering details, such as number and capacity of cranes and capacity of motors for the various applications of the foundry, but to analyze the general conditions and give data that will assist in arriving at proper power house equipment and systems of power best adapted to the conditions.

E. O. T. CRANES, MAIN FLOOR, PITTSBURGH STEEL FOUNDRY.

A thorough analysis of several large steel and iron foundries was made with particular reference to electrical installations, operating conditions and power requirements. These foundries were of the modern type, with electrical drive throughout, and were equipped with overhead traveling cranes in each department. The capacities ranged from 1,500 to 2,000 tons per month, and the weight of the castings ranged from 100 pounds to 100,000 pounds, with an average of 250 pounds. The electrical equipment was 220-volt, direct current, with one exception, which included 400-volt, 3-phase, alternating-current machines. The average conditions for these foundries were as follows:

FLOOR MOTORS.

	NO.	SIZE	TOTAL H. P.
Air compressor	1	75	75
Cold saws	2	20	40
Sand mills	2	30	60
Grinders	8	5	40
Machine shop	6	..	50
Repair shop	1	25	25
Miscellaneous	5	..	39
Total	25	..	329

CRANES.

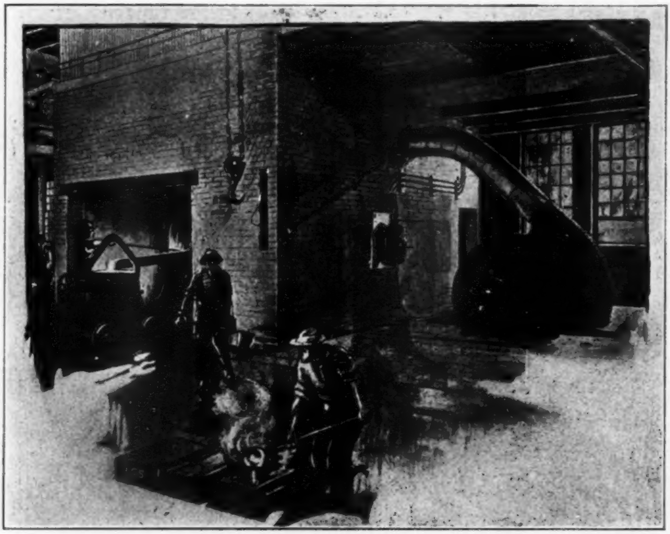
NO.	CAPACITY	TOTAL H. P.
2	50 tons	280
3	25 "	250
4	10 "	180
2	5 "	90
11		800

Total, floor motors .... 329 H. P.
Total, crane motors........................ 800 H. P.
Total, crane hoist motors.................. 400 H. P.

A general rule for power house capacities is that the average load will be approximately 1/3 the total capacities of floor motors and crane hoist motors. In figuring the crane load on the power

MOTOR-OPERATED, DIRECT CONNECTED, ADJUSTABLE GRINDER.

station, it is to be noted that as the hoisting motion of the crane gives the heaviest load, and as it is seldom that more than one motion is used at a time, it is sufficient to consider the load on this motor only. As the crane work is very intermittent, the load is very fluctuating, and the total capacity of the power generators should not be less than twice the average load. As a general



AMERICAN BLOWER CO. MOTOR-OPERATED, DIRECT CONNECTED CUPOLA BLOWER.

rule, a spare generating unit will prove a paying investment to insure ample power at all times.

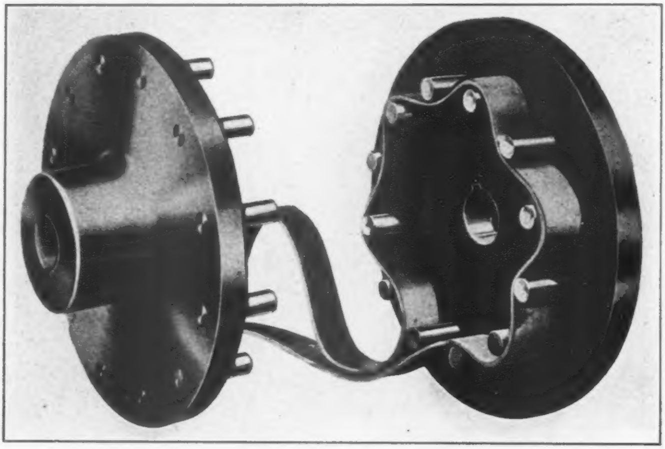
For the above conditions the average power house load $= \dfrac{329 + 400}{3} = 243$ H. P. $= 181$ K. W., and two 175-K. W. generators would be sufficient.

Or, figured on another basis, it requires approximately 35 K.W.-hours per ton of steel castings, and approximately 45 K. W.-hours per ton of iron castings, for foundries with electrical equipment and capacity as given above. The blast for the cupo-

las of the iron foundry, and the greater amount of small work, increases the electric power per ton output.

The values given for power house capacities include power for lights and other auxiliaries, such as electric welding for steel foundries and machinery for repair shop and pattern shop.

The following general conditions for foundries, as mentioned above, have been established. The capacity of the floor or constant speed motors is approximately equal to the capacity of the crane hoist motors.



FLEXIBLE COUPLING FOR DIRECT CONNECTED, MOTOR-OPERATED BLOWER.

(1) The average station load equals 1/3 the total capacity of floor motors and crane hoist motors.

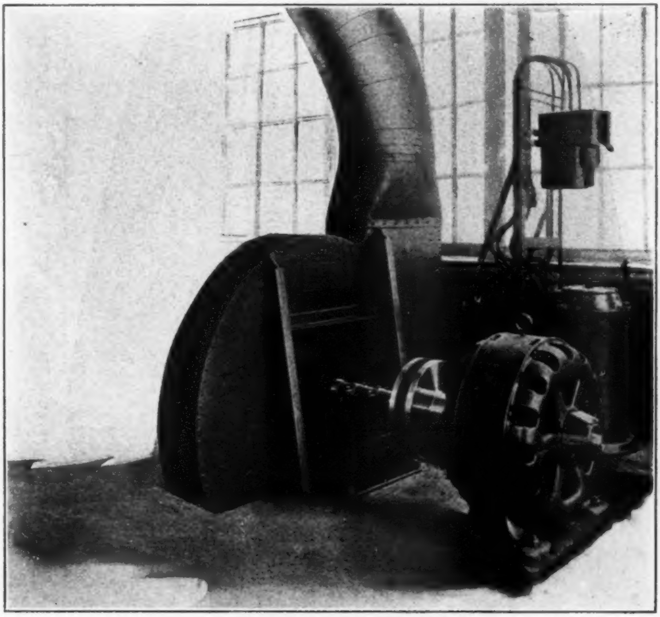
(2) The maximum station load equals approximately twice the average load.

(3) The average distance for distribution of power is 600 feet or less.

(4) The application of adjustable speed motors are few except where considerable machine work is done, in which case the power required will seldom be over 15 per cent. of the total station capacity.

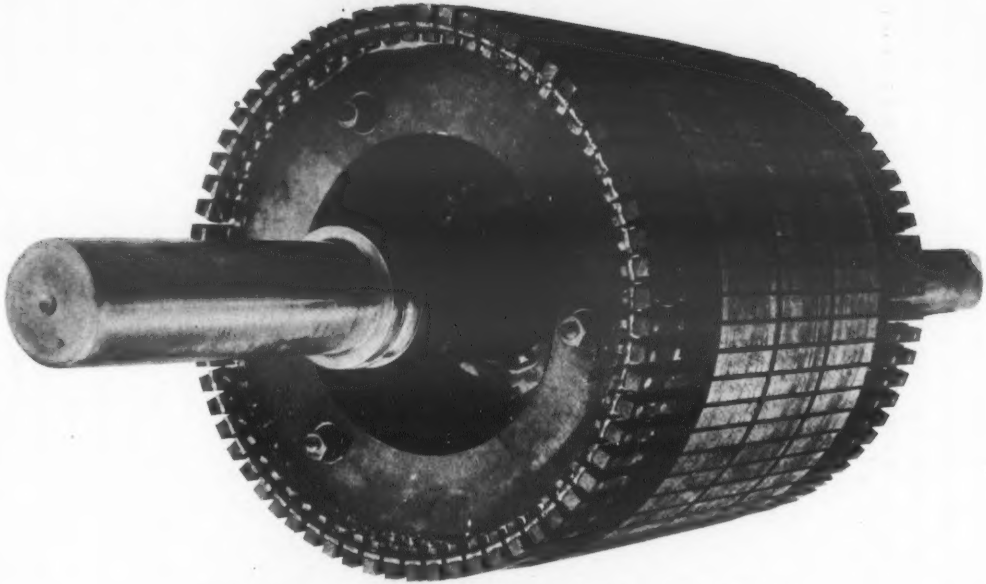
(5) The lighting load will average from 10 to 12 per cent. of the total load.

The majority of the motor-driven foundry apparatus is located in the main working rooms and is, therefore, subject to a very dusty and gritty atmosphere, and this is particularly so in the cleaning and grinding departments. While in the past it has been almost a universal practice to connect the motors to the



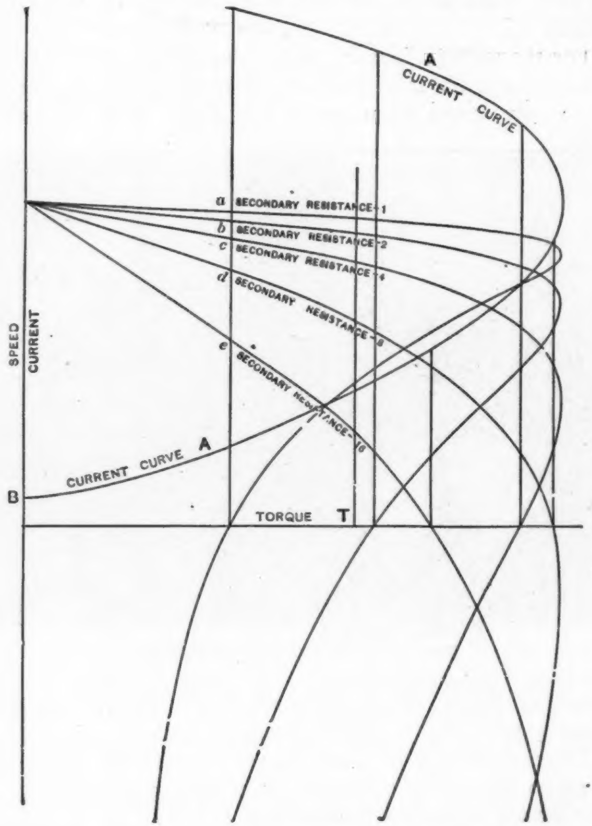
MOTOR-OPERATED, DIRECT CONNECTED BLOWER.

driven machines by means of belting, there is a decided tendency at this period to connect the motor in a more direct manner, either by gearing or direct drive. This applies particularly to grinders, machine tools, air compressors, fans and blowers. There is excessive wear of the belt on account of the grit and dust in the air, and on account of slippage due to overloads, and, in some cases, such as grinder, considerable power is saved by a more direct connection of the motor.



ROTOR OF WESTINGHOUSE TYPE "MS" SQUIRREL CAGE INDUCTION MOTOR.

The present designs of motors have been developed to meet these improved methods of drive. The frames, and especially the shaft and bearings, are made stronger, and arrangements are provided to dustproof the bearings. The windings are of a more



CHARACTERISTIC CURVES—ALTERNATING CURRENT MOTOR—WOUND ROTOR TYPE.

substantial form and are well braced, and, from an electrical standpoint, improved characteristics are provided, such as high starting torques, excessive overload capacities and greater range of speeds.

In general, a decided improvement has been made in the all-over efficiencies and reliability of motors for this class of service.

The most common electrical questions are: Which is the better system to adopt, alternating current or direct current? Why and what should be the characteristics of the system adopted?

For the average foundry, as previously described, in which crane service is the most important feature, and the power station capacity ranges from 300 to 500 K. W., with the average

SPECIAL DOUBLE END GRINDER MOTOR.

distributing distance approximately 600 feet, the 250 volt direct current system offers many advantages.

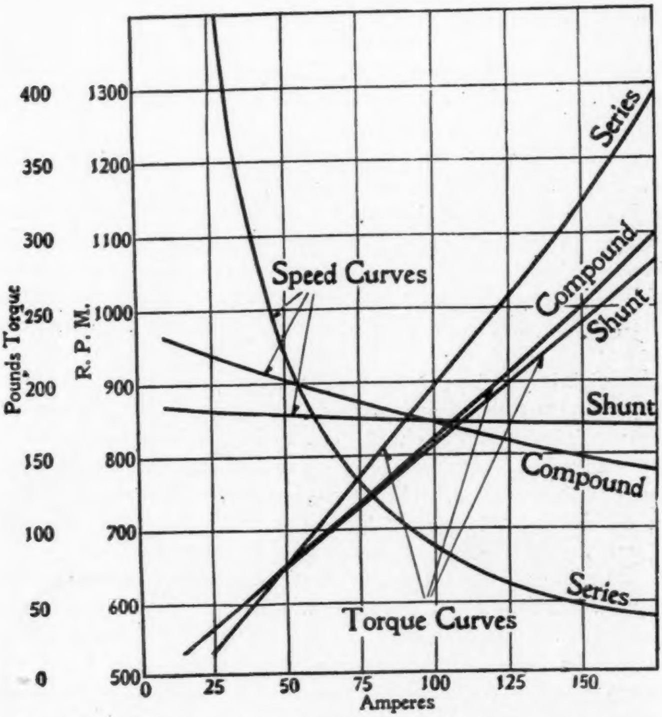
Direct current motors can be used for all the applications and as no converting apparatus or exciters are necessary, the power station equipment is simplified.

Direct current series motors have a speed torque curve, especially suitable for crane work, as the speed varies with the load. The motor gives rapid acceleration, due to large starting torques obtainable and it will stand excessive overloads.

Direct current, adjustable speed motors are especially suit-

able for machines such as the lathe and drill press, which may require a speed range of 2 to 1 or even more, and also for cupola blowers, where speed change is desirable.

As the distance of distribution of power is short, 250 volts



CHARACTERISTIC CURVES—SHUNT, COMPOUND AND SERIES WOUND DIRECT CURRENT MOTORS.

is sufficient to permit a low line loss with a reasonable cost for copper.

In the case of foundries producing small size castings, the overhead traveling crane is seldom used and the floor machinery constitutes the principal motor applications. The alternating current system offers many advantages for this class of foundry, namely, simplified and more durable construction of motor, better

lighting system and other advantages mentioned under the subject of central station power.

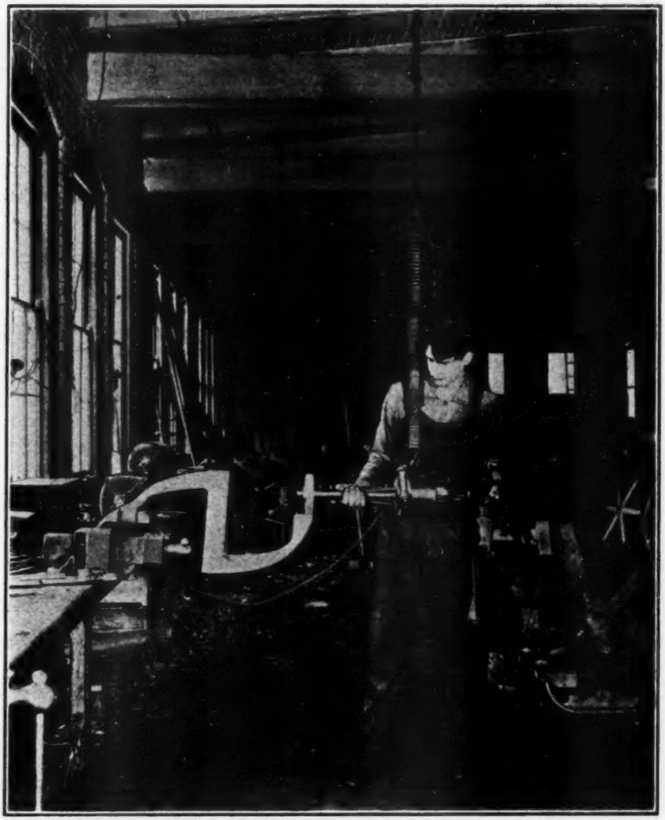
At this point, it would be well to discuss the question of power proposition as offered by the large central station companies. It will be noted that the foundry power load is very fluctuating, giving approximately a 50 per cent. load on the station. This means exceedingly low steam economy, especially with reciprocating engines. The foundry station is comparatively small and is in operation 24 hours a day, therefore should contain a spare unit for emergencies.

All of these factors tend towards a high cost of power. The central station being of large capacity, does not feel the direct effects of the load fluctuations for the peaks of the various loads tends to overlap in such a manner that a more uniform load condition exists. The load being practically continuous, improves this load factor. Thus, to the small plant, especially, the central station companies can often offer good inducements to purchase power.

Lighting is the principal load of the central station and the system most generally adopted is alternating current, 3-phase, 60 cycle. The power is either generated at a high voltage or is stepped up to a high voltage by means of transformers for economy of transmission. The alternating current system thus offers a decided advantage over the direct current system when the question of transmission is much of a factor.

In the case of an existing plant having direct current motors installed, a rotary converter could be used to convert the power to direct current of suitable voltage. If the proposition relates to a new plant, there a more economical plan will be to use alternating current motors, although in a majority of the cases, it will be necessary to reduce the voltage. Usually, the transmission voltage will be over 1,000 volts and transformers should be used to give 240 volts for distribution within the foundry. Considerable discussion has taken place between the electrical engineers of the iron and steel industry during the last two years regarding the most suitable voltage for inner works distribution and from a safety standpoint, it has been decided that 240 volts for 220-volt alternating current motors and 250 volts for 230-volt direct current motors should be used and these voltages are becoming standard for this class of industry.

The alternating current squirrel cage wound motor offers several advantages over the direct current motor for the floor machines with the exception of the applications requiring adjustable speed, such as machine tools and for these applications, it would be best to install a small motor generator, set to give direct current. The advantages are as follows:



PORTABLE ELECTRIC GRINDER.

Simple construction of windings and especially the rotating

element with the attendant advantages of absence of commutator and wearing parts, such as brushes, ability to stand excessive overloads. These several advantages mean less up-keep cost and in a general way, more reliability.

While it is true that the characteristics of the direct current series motor is more suitable than the alternating current motor for crane service, very satisfactory results are given by the latter and in the case of a foundry purchasing power from a certain station, where it would be necessary to install converting apparatus to obtain direct current, the increased cost of installation and loss of efficiency will hardly warrant installing a mixed system.

Some of the principal reasons for purchasing energy from the central station are as follows:

Investment for power apparatus limited to motors and wiring. In new installations, the cost is usually less than for mechanical systems of power distribution.

No investment for land, or floor space for power equipment.

No investment for power plant and repair parts.

The money saved by the lack of power house may be invested in the business where it will return its share of profit.

The production and marketing of the power is a sole reason for the existence of the central station, consequently every effort is made by the management to improve the service in every possible detail. Power absolutely reliable.

There is no possible chance for complete shut down, due to an accident to any machine. The reliability of supply is in no respect dependent on one man's watchfulness; seldom is a skilled workman required in the factory to care for the power equipment.

No high pressure boilers and no opportunity for explosion.

No delays, due to insufficient power.

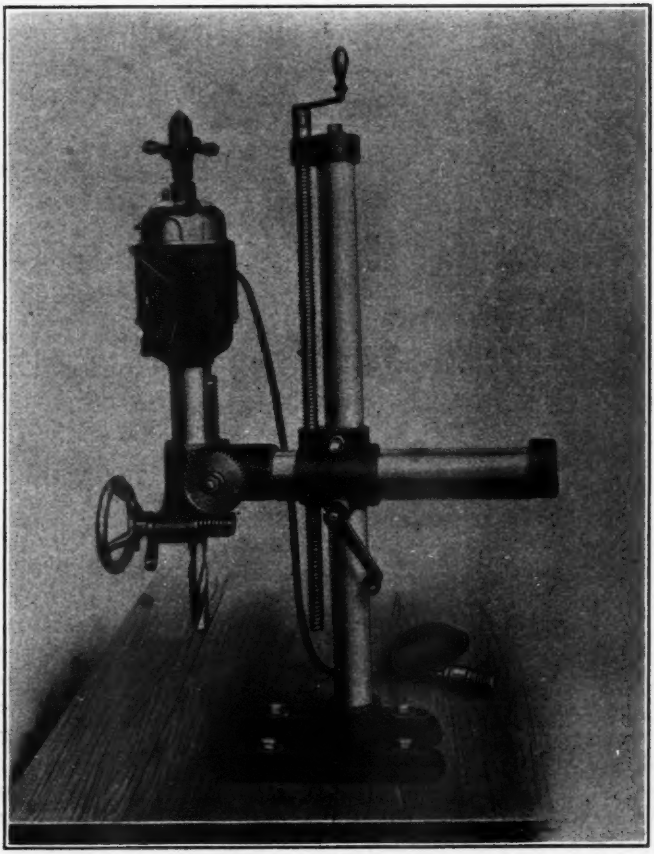
Cost of overtime work, per machine, no more than for the regular operation.

The power cost is directly proportional to the factory output, since the power consumed is proportional to the work done.

No increase in power plant equipment required for factory extensions; the central station takes care of all increases in the demand for power.

Electric power may be tried for a more or less extended

period, and proven satisfactory, without making expensive changes in the equipment before extending it throughout the factory.



MOTOR-DRIVEN RADIAL DRILL.

Owing to the larger size and to the use of voltage regulating devices, central stations provide a steady voltage without undesirable fluctuations.

Referring again to the subject of power supply, the coal consumption (using good grade of coal) is 10 pounds to 12 pounds per kilowatt hour for the average condition of load, varying from 30 per cent. to 125 per cent.—average 50 per cent. This means that the efficiency is about 25 per cent. less than a uniform load, ranging from ¾ to full load. For these conditions, especially, the auxiliary pole, direct current generator offers several advantages—the commutating conditions are greatly improved, and the practical overload capacities are increased.

While it is possible to obtain a load which will be uniform within 5 or 10 per cent., by means of a storage battery, it is questionable whether it offers a paying advantage for the average conditions. However, in the case of one plant inspected, the crane capacity is exceptionally high, including 20 cranes of 385 tons and the total of floor motors is 600 H. P.

The original installation of the power house included 2-150 K. W., 250 volt generators, but it was soon discovered that the peaks were excessive on account of the heavy crane loads. To equalize the load on the generators, a storage battery of 116 cells was installed, having a discharge capacity of:

80 amperes	........8 hours	........1.8 volts per cell
112 "	........5 "	........1.75 " " "
160 "	........3 "	........1.7 " " "
320 "	........1 "	........1.6 " " "

With this addition, the station can now be operated for 9 out of 10 hours with one engine and battery, and the generator load does not vary more than 10 per cent., and during the other hours the second engine is used to help carry the load and charge the battery.

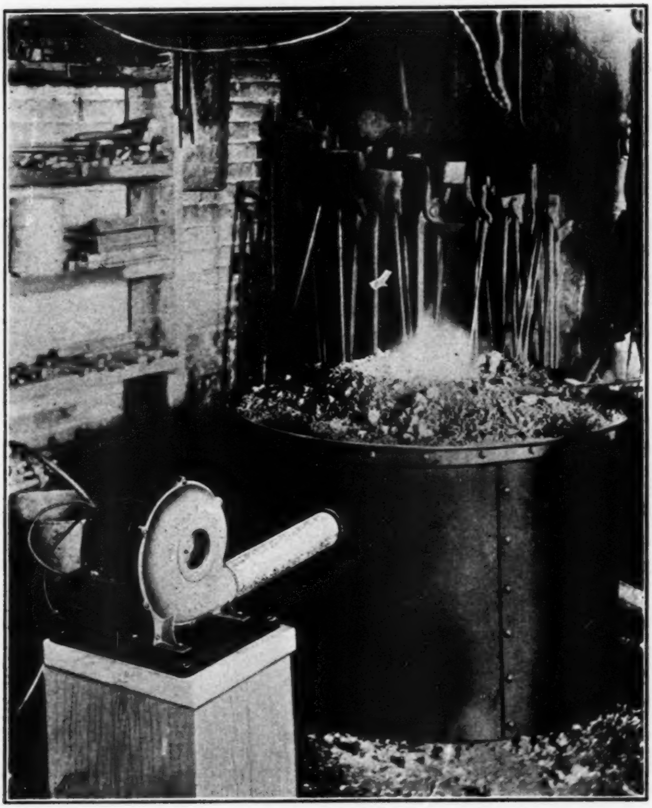
If the battery had not been installed, an additional generator would have been required, and the three units would have operated at a very poor efficiency.

A steam turbine offers but little advantage when such small capacity of unit is considered, as the steam consumption is practically the same as that for simple steam engine, being possibly somewhat higher at full load and lower at the lighter loads.

In the case of plant enlargement it would be well to consider

the low pressure turbine using the exhaust steam from the existing engines. By this means, at least 75 per cent. additional power can be obtained without an additional coal consumption.

As a brief summary regarding the power station, the gene-



INDIVIDUAL FORGE BLOWER, OPERATED BY WESTINGHOUSE TYPE "DZ" MOTOR.

rator units are of comparatively small capacity, and as the load is extremely fluctuating and has a low average value, the allover efficiency of the plant is rather low, being at least 25 per cent. below efficiency when operating continuously at normal

capacity. It is very doubtful if the average steam plant of the foundry, under the most favorable conditions, regarding price of fuel, etc., can produce the power for less than 2 cents per K. W. hour, and for the majority of the plants the cost will be even higher. Only a few of the plants are equipped with instruments for measuring the total power, and for a new plant especially, it is recommended that integrating meters be installed and an accurate record of power conditions be kept. It is not sufficient to base an estimate for a particular plant on the records of a few days, but rather on the average of several months. Other data, relating to power costs, should be recorded, and a definite cost established. Until this is done, the question of power economies cannot be analyzed with any degree of accuracy, and the advantages of the various suggestions which are sure to be considered from time to time, established.

One of the most important applications of electricity in the foundry is that of lighting. The natural conditions of dust and dirt as well as steam in the air, the crowded condition of the floor and the preponderance of dark surfaces, present difficulties, which make satisfactory lighting for the foundry a very much involved question. The light must be well distributed and of good intensity and necessarily penetrating. These requirements must be met to insure the efficiency and accuracy of the work of molding especially, and as a precaution against accident in the general work of the foundry, particularly on the pouring floor.

Have you ever stopped to consider what an exceedingly small percentage of saved time it takes to pay a large return on an investment for improved lighting? It is safe to say that a saving of ten minutes a day, per man, would more than pay for doubling the lighting of the average foundry, and, in fact, almost any factory.

Manufacturers in general are giving this subject of lighting much more consideration than ever before, for the illuminating engineer has been wonderfully successful in proving the effectiveness of his service. To give this subject due prominence, would require more time and space than can be properly allotted in this paper, and as it is such an important factor in the economics of foundry practice, it is recommended that this question of illumination be carefully reviewed and further analyzed and made the topic of special papers.

THE ANNEALING OF STEEL CASTINGS.

By Bradley Stoughton, New York City.

The annealing of steel castings is not always a necessary operation in their manufacture, and especially in the manufacture of small steel castings which have not great length to produce severe strains by shrinkage. While it cannot be denied that proper annealing must benefit all steel castings in greater or less degree, on the other hand, annealing, as too frequently practiced, is often more of a detriment to some castings in the heat than it is a benefit to the remainder. Annealing has the two-fold purpose of relieving any strains produced in the metal during cooling in the mold, and of improving the strength and ductility of the metal by breaking up the coarse structure inevitably developed to some extent during cooling from solidification and, in some cases, amounting to that extreme degree of coarse crystallization which causes the appearance known as "ingotism." Annealing to relieve strains is a comparatively simple operation, concerning which I shall not take any more of your time to-day, but annealing, to produce the best grain obtainable, which shall in turn give the highest possible combination of strength and ductility to the casting, is an operation so often imperfectly understood and crudely practiced in foundries, that I hope an interchange of ideas may be of benefit, even though I cannot offer anything new or revolutionary for consideration.

The microscope and some form of pyrometer, however crude, is an invaluable adjunct to annealing practice. The time has passed when steel foundries can obtain the best results in competition by means of the unaided eye. The pyrometer will tell us when the steel has reached that temperature which will give to it the best grain, and, therefore, the best physical properties, while the microscope will tell us whether or not this heat treatment has performed its work as thoroughly as it should. If the structure of the casting, after its first solidification is not excessively coarse, heating it slightly above its critical temperature, maintaining it there until the heat has penetrated to the

FIG. 1.—Steel of 0.50 per cent. carbon. Grain of rolled steel. Magnified 40 diameters.

FIG. 2.—Same steel as Fig. 1. Coarse grain due to heating to high temperature. Magnified 40 diameters.

FIG. 3.—Same steel as Fig. 2. Reheated to "refine" the grain. Note skeleton structure showing outlines of former large crystals. Magnified 40 diameters.

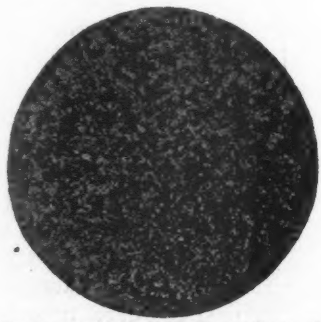


FIG. 4.—Steel of 0.05 per cent. Grain of rolled steel. Magnified 40 diameters.

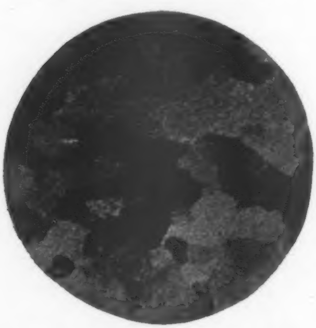


FIG. 5.—Steel of 0.05 per cent. carbon. Coarse grain due to heating to high temperature. Magnified 40 diameters. Same steel as Fig. 4.

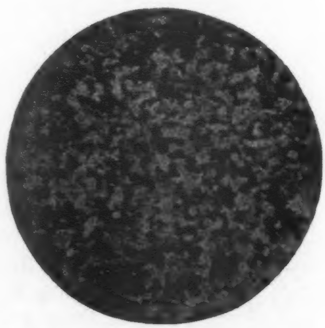


FIG. 6.—Same steel as Fig. 5. Reheated to "refine" the grain. Magnified 40 diameters.

most remote point, and then for about one-half hour thereafter will produce the desired result. But, if the steel has been cast at an excessively high temperature, or if it cooled with unusual slowness through the first 200 degrees or 300 degrees after solidification, of if, in any other way, an unusual coarse and open crystalline structure has been produced, the process of annealing described above, even if protracted beyond the time limits mentioned there, will not completely obliterate the coarse crystals. The large crystals will be broken up into smaller ones it is true, nevertheless a sort of skeleton work, showing indistinctly the boundaries of the previous large size crystals will

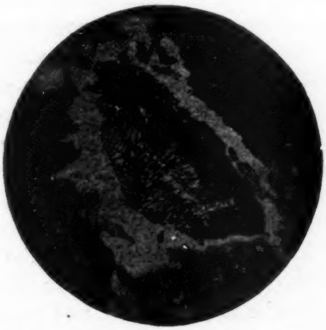


FIG. 7.—Steel cooled very slowly from 1650° to 1200° F. Magnified 250 diameters.

persist, and the steel will be somewhat below normal in strength and ductility, or both.

This point will be well seen by reference to Figures 1, 2 and 3. Fig. 1 shows fine grained steel as produced by forging or rolling; Fig. 2 shows the same steel in a very coarse crystalline state; while Fig. 3 shows the same steel after again reheating above its critical temperature. It will be seen that the large crystals are broken up into smaller ones, but there still persists a skeleton work showing the outline of some of the coarse grains.

Figures 4, 5 and 6, on the other hand, show steel in a finely grained condition; the same steel with a coarse structure, and, finally, this coarse structure refined almost to its original condition.

In order that the steel shown in Fig. 3 might be refined as completely as that shown in Fig. 6, two steps in the annealing would be necessary. The coarse grained steel would first have to be heated for an hour or more, after complete soaking, at a temperature far above its critical temperature. This would produce a structure intermediate between that of Fig. 1 and Fig. 2, and would obliterate the skeleton work showing the outlines of the previous coarse crystals. Such a casting must then be cooled to a black heat and subsequently reheated slightly above its critical temperature in order to give it the best possible physical qualities. This double process of course involves a waste of time, heat and labor, and the bad quality of the coarse structured steel may not always be bad enough to justify this expenditure, but it should be remembered that this double process —and this alone—can redeem steel castings of extraordinarily coarse crystalline structure.

Another point about the annealing of steel castings, which is not often emphasized, is that slow cooling through that limited interval of temperature known as the "critical range" is detrimental to both strength and ductility. Slow cooling below 1,200 degrees F. will improve the ductility of the metal, but slow cooling from 1,700 degrees down to 1,200 degrees F. develops thicker grains of ferrite and cementite and reduces both strength and ductility. Fig. 7 shows the structure of steel which has been cooled very slowly through this interval, and illustrates the fact to which I have alluded. Fig. 8 shows the critical range of steel and iron. Most of our steel castings contain less than 0.50 per cent. carbon and, therefore, the critical temperatures above which they are to be reheated are located in the line GO. To cool the steel slowly from above the line GO to below the line PSK, will develop thick crystals of ferrite and cementite.

Because of this circumstance there has arisen a process of annealing which consists in maintaining the steel castings above their critical temperature about half an hour after they are completely soaked, then pulling them out so the air will blow upon them until they are black heat; after which they may or may not be returned to the furnace and allowed to cool as slowly as they will. Of course, it must be remembered that this

method of annealing may set up strains in castings of very complicated shape, and the castings must also be so piled that they will not strain each other during the expansions and contractions which they undergo whilst cooling through the critical interval.

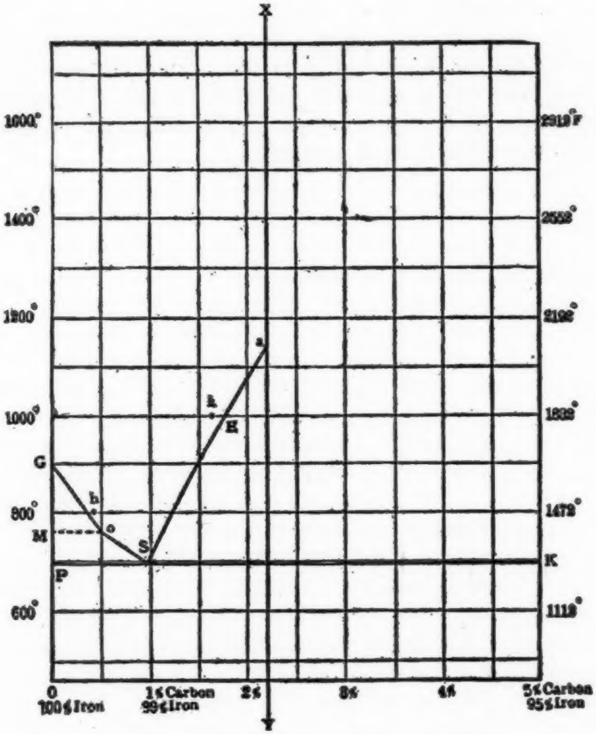


FIG. 8.—THE CRITICAL RANGES OF IRON AND STEEL.

It may be of interest to the foundrymen here present to know that Seger cones may be purchased from the chemical supply houses and elsewhere and serve a valuable purpose in annealing work. These Seger cones are little forms of clay, melting at a great variety of temperatures. If these cones be placed in a furnace along with the castings, their melting

will show when any particular temperature is attained. It is also possible to put cones in different parts of the furnace to determine the uniformity of the heat.

An ordinary horseshoe magnet is a valuable adjunct in annealing steel castings, because castings of 0.50 per cent. carbon and less, lose the power of attracting a magnet when they reach a temperature of 1,550 degrees F., so that in this way we can check up the eye in estimating the temperature of the annealing furnace, and this is especially valuable, because this particular temperature (i. e., 1,550 degrees F.) is only a short distance below the correct one for annealing.

MECHANICAL CHARGING OF CUPOLAS.

By G. R. Brandon, Harvey, Ill.

In a paper read before the Pittsburgh Foundrymen's Association, in March, 1908, the writer discussed the subject of Charging Machines for Cupolas, and described at that time the designs which had been developed by the Whiting Foundry Equipment Co. In the interval since, several new types have been brought out to meet special operating conditions, and these, with the designs previously referred to, will be illustrated and described, together with other equipment employed in handling charges.

It is evident from the interest aroused in methods for reducing the cost of handling cupola stock, that this subject is considered of great importance by foundry managers. There is no department in the foundry in which greater returns will result from the adoption of a scientific plan of operation. Every movement from the time stock arrives in the yard until charged into cupola must be carefully studied, and facilities provided to eliminate manual labor wherever possible, and make this labor most effective when necessary to depend on it.

I will consider first, briefly, layout of the storage yard and means for handling the stock. Assuming a foundry of moderate capacity, for which ample ground for an accumulation of stock will be provided, materials should be delivered on cars on railroad switch track running parallel to length of foundry on the side where cupola house is located. The distance between foundry building and this track should allow space for storage adjacent to railroad switch, and for a narrow gauge yard track between storage piles and building. It is evident that the layout of stock yard will depend upon local conditions, but the principles here given will be applicable in any plant.

Pig iron should be piled in yard, with a label on each pile, giving brand and grade of iron, also initial and number of car on which iron was received. A good plan is to mark pigs near the bottom layer of the pile which will not be disturbed until pile is nearly used. From the car records the analysis and com-

FIG. 1.—YARD CRANE FOR CANADIAN PACIFIC RAILWAY.

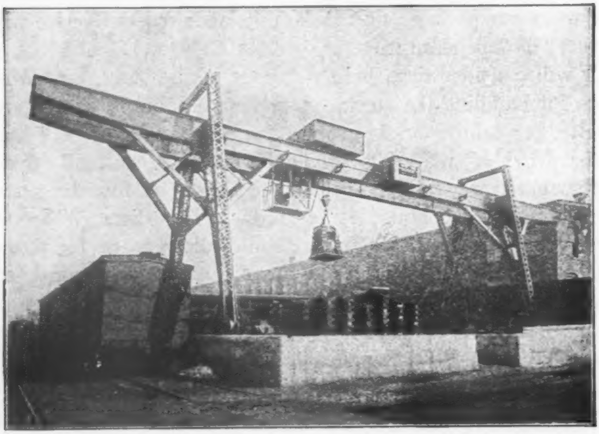


FIG. 2.—ELECTRIC GANTRY FOR ST. L. & S. F. R. R. CO.

plete information regarding the particular carload should be obtainable. Scrap iron is simply dumped into bins, different grades being kept separate. Coke should be stored in covered bins. When the tonnage handled is sufficient to make the investment profitable, a traveling or gantry crane covering storage yard should be installed. It should have high speed movements and be fitted with a magnet for unloading pig and scrap, and for manipulating drop weight for breaking scrap. This crane could also be used for handling heavy flasks in and out of storage, and for loading castings to be shipped. Crane may be fitted with grab bucket to handle coke and limestone. A jib crane may be substituted for traveler in smaller plant and perform similar functions, to a limited extent. Fig. No. 1 illustrates an electric traveling crane covering foundry yard, and Fig. No. 2, an electric gantry with magnet, such as could be used.

Disregarding the primitive methods still occasionally found employed, of using barrows and dumping stock on charging floor to be rehandled in making up charges, and again to charge into cupola, I will briefly review various modern methods of handling cupola stock from yard to cupola. Charges should be collected on cars, the proper amount of different grades being selected and weighed, and not again handled until introduced into cupola. Cars of two tons capacity, properly constructed and equipped with roller bearings for axles, can easily be pushed over level tracks by one man. When warranted by conditions, an electrically operated transfer car may be used to transport charging cars, while charges are being collected. A scale may be mounted on transfer to weigh charges, if desired. After charges are weighed, cars are elevated to charging platform by means of elevator, or if yard crane is available, cars may be constructed with means for attaching slings and the car, with charges, lifted intact to charging floor, but this latter method is not an economical one, and is only permissible in case of accident to elevator. Iron and scrap may be elevated to charging floor with magnet crane, but this method requires additional space on charging floor and involves extra handling, and is, therefore, not recommended.

Storage space for about 50 per cent. of melt in one heat should be provided for on charging floor, and a sufficient number of cars to carry this stock must be supplied for convenience and

economical operation. As soon as emptied, cars are lowered to the yard and charges replenished for a later period in the heat. A system of tracks on charging floor should provide for constant forward travel of cars and an open track to elevator for cars that have been unloaded.

If desired, cars may be provided with flat tread wheels, suitable for plate floor, or with combination wheels, which may be used both on track and plate floor. A special design made by the Whiting Co. has platform overhanging at one end, so that

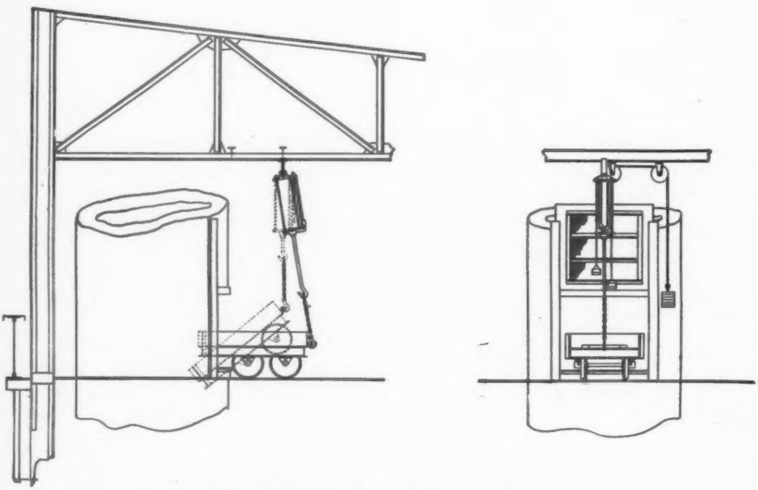


FIG. 3.—CHARGING CUPOLA BY MEANS OF BALANCED CAR.

when load is properly adjusted it will almost balance on one axle. By means of handle at other end of car it may be readily turned and pushed in any direction. When proper arrangements are made charges may be dumped into cupola from this car. It is backed up to charging door, wheels blocked, and forward end lifted by suitable hoist. This device is shown in Fig. No. 3. Cars with hinged bodies may be dumped into cupola, the charge falling by gravity on releasing lock pin. Dump barrows are used

with the same effect. The skip car, operating on incline, with automatic dumping device, is also in use in connection with cupolas.

Another device for charging cupolas mechanically, consists of a trolley operating on jib of a crane or on a track which extends into the cupola. Charges are made up as desired in a cylindrical bucket, with drop bottom doors, which is carried on this trolley. Hoisting and trolley travel movements are operated by power, and drop doors opened by releasing a latch.

The Whiting charging machine is used in connection with

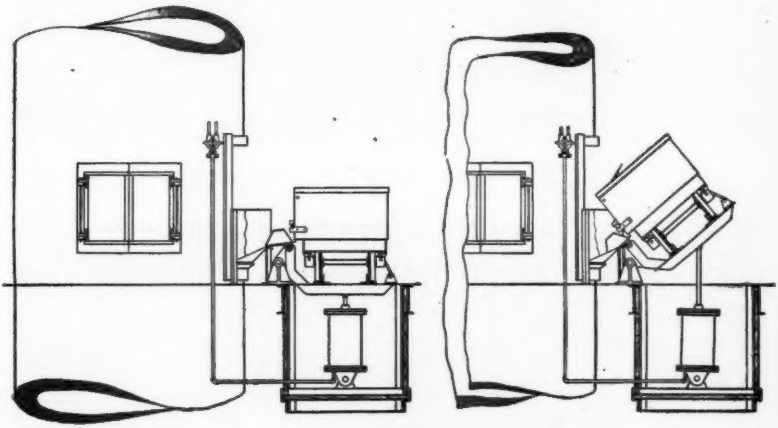


FIG. 4.—SIDE DUMP CHARGING MACHINE.

simple design of car, having steel plate ends about 12 inches high for iron charges and having plate body with swinging side door, hinged at top, for coke. On the side dump machines, cars are pushed on to a hinged platform, locked with simple hook which engages loop on car frame, the platform and car are raised together by power, and charge dumped. The distribution is under perfect control of operator, the charges being delivered to farther side of cupola by a sudden, and to near side by a slow, hoisting movement. Fig. No. 4 gives two views of this machine. Figs.

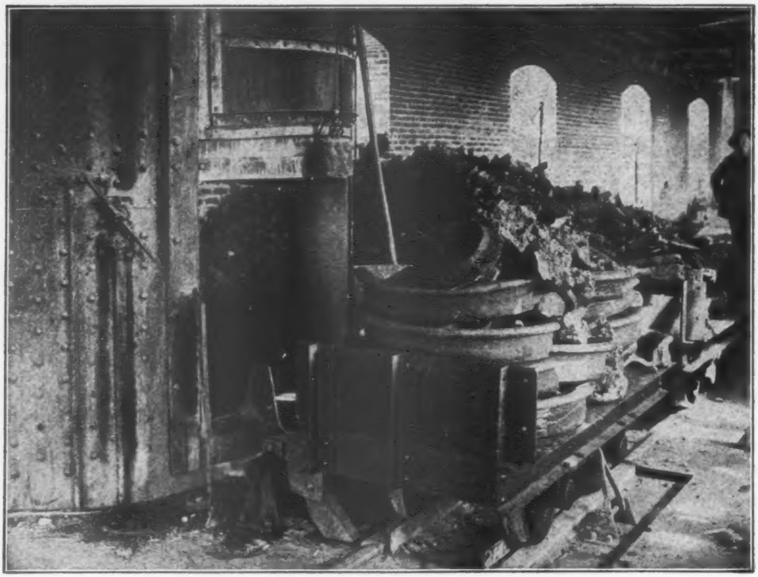


FIG. 5.—SIDE DUMP CHARGING MACHINE READY TO DUMP.

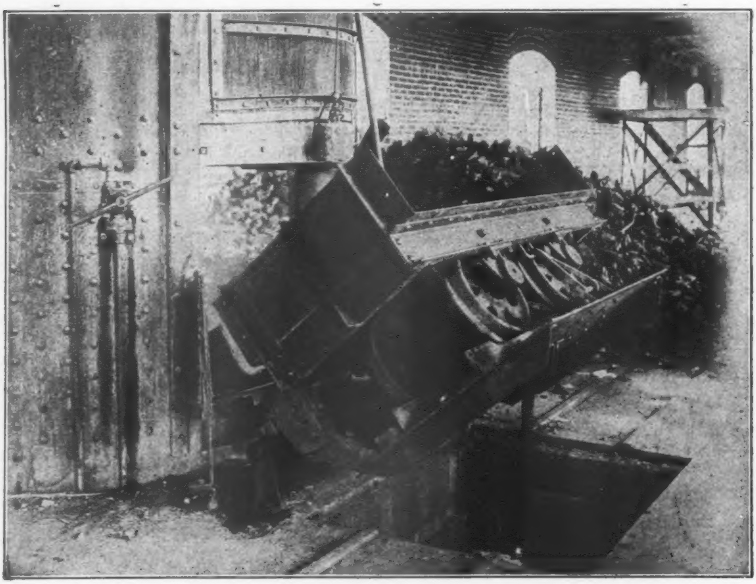


FIG. 6.—SIDE DUMP CHARGING MACHINE IN DUMPING POSITION.

No. 5 and No. 6, reproduced from photographs, illustrate respectively, this machine ready to dump and in dumping position. End dump machines are supplied when conditions require it, but side dump cars are preferred, as cars do not have to be turned to place on machine. Fig. No. 7 reproduces drawing of end dump machine. The compound machine is recommended for situations in which charging floor is too low for greatest efficiency of cupola operation. The hinged platform with car on it is first

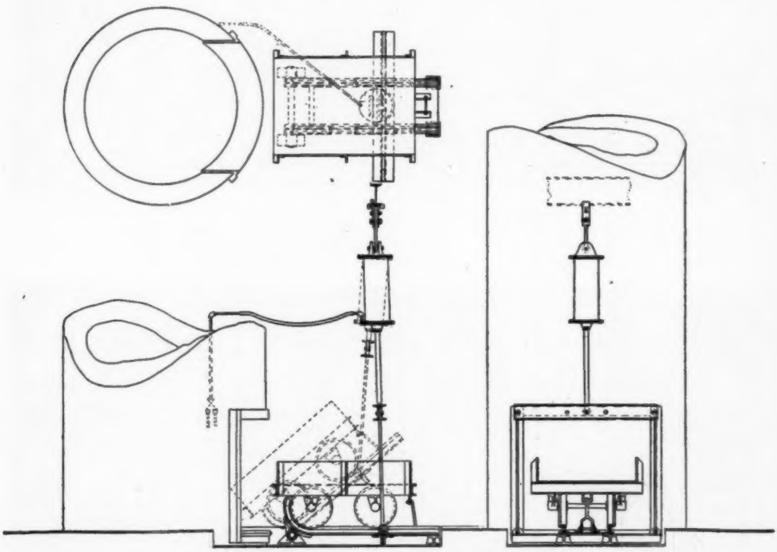


FIG. 7.—END DUMP CHARGING MACHINE.

raised to proper level and at that point is dumped by means of separate power device in a manner similar to the plain machine.

Fig. No. 8 is from drawing of compound machine. Figs. Nos. 9 and 10 show actual installations. On above machines, pneumatic cylinder hoists furnish the power. Electric geared hoists may be substituted for pneumatic hoists. For electric compound machine, only one hoisting mechanism is required as the design provides for the inclination of platform without inde-

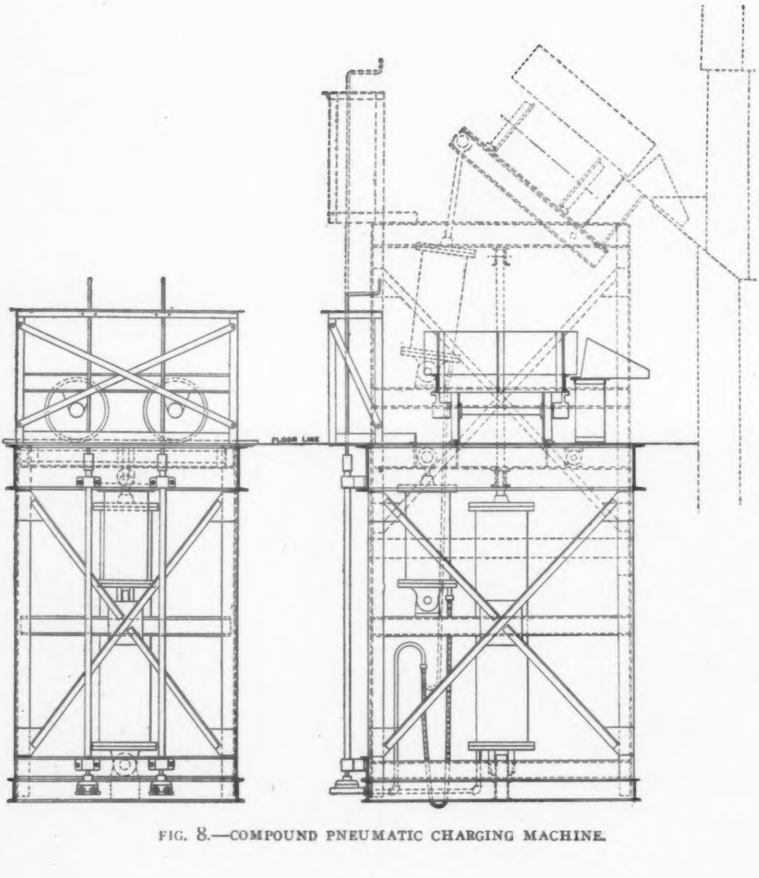


FIG. 8.—COMPOUND PNEUMATIC CHARGING MACHINE.

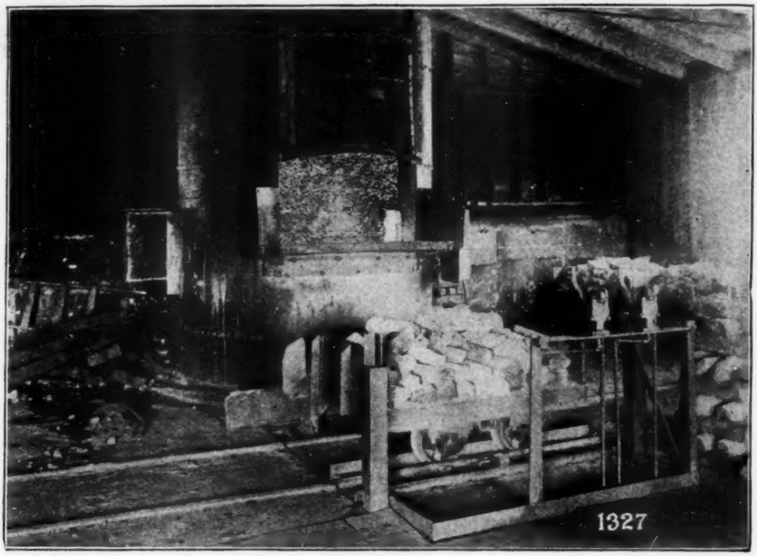


FIG. 9.—INSTALLATION OF COMPOUND CHARGING MACHINE FOR PIERCE, BUTLER & PIERCE CO., SYRACUSE, N. Y.

FIG. 10.—INSTALLATION OF COMPOUND CHARGING MACHINE FOR PIERCE, BUTLER & PIERCE CO., SYRACUSE, N. Y.

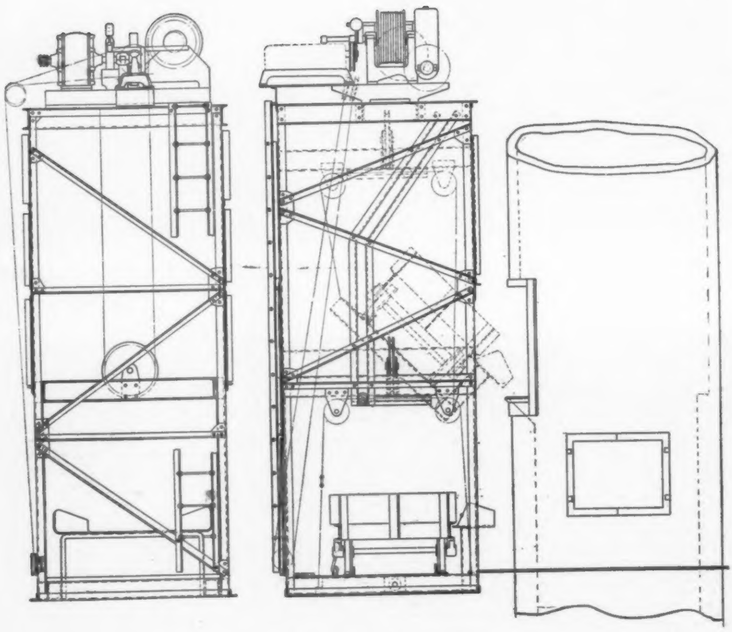


FIG. 11.—ELECTRIC COMPOUND CHARGING MACHINE.

FIG. 12.—INSTALLATION OF ELECTRIC COMPOUND CHARGING MACHINE, D., L. & W. R. R., SCRANTON, PA.

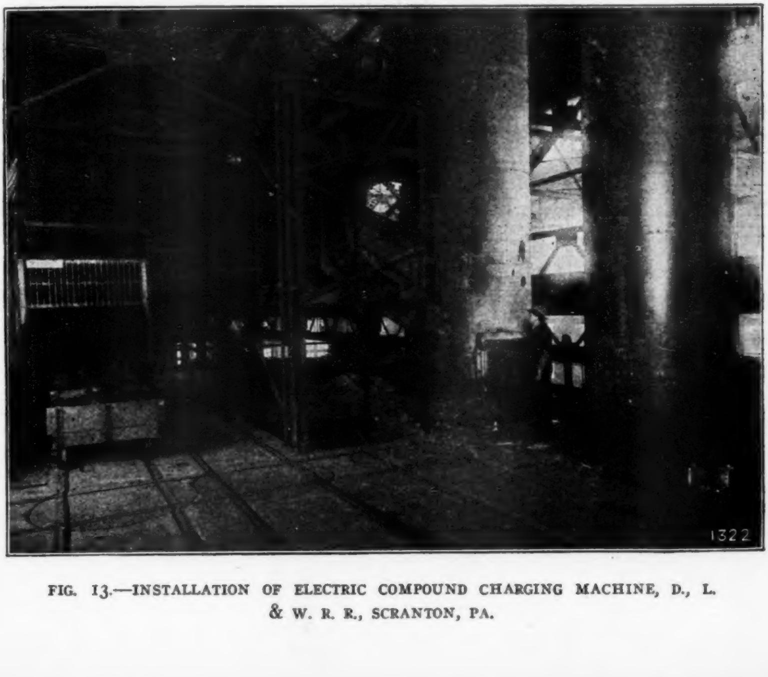


FIG. 13.—INSTALLATION OF ELECTRIC COMPOUND CHARGING MACHINE, D., L. & W. R. R., SCRANTON, PA.

pendent hoist. Crane type of controller is used, allowing wide range of speeds, which permits uniform distribution of charges. Fig. No. 11 reproduces drawing, and Figs. No. 12 and No. 13 illustrate installation in D. L. & W. foundry, Scranton, Pa.

The charging door in cupola used in connection with charging machine is larger than the ordinary door for hand charging

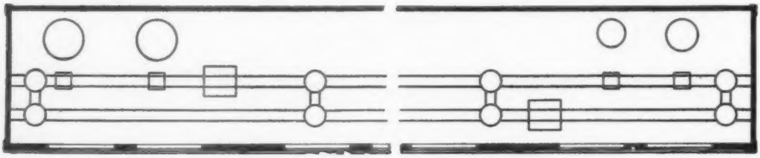


FIG. 14.—CHARGING FLOOR, CANADA CAR CO.

and is set lower. An inclined chute is arranged to receive the stock as dumped from the car. Charging machine is provided with an apron plate which overlaps chute and prevents iron dropping from car to the floor.

A vertical distance of four or five feet between top of stock in cupola and the sill of charging doors is necessary to provide

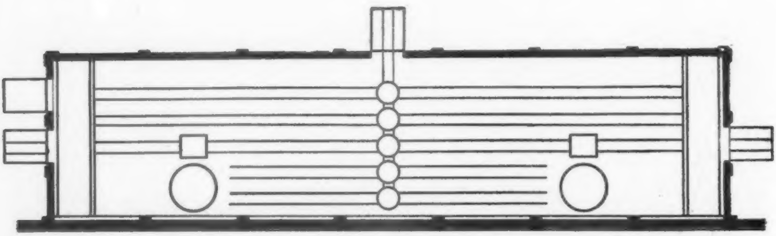


FIG. 15.—CHARGING FLOOR, AMERICAN CAR & FOUNDRY CO.

space for distribution of charges. Therefore, charging floors should be higher than when charging is done by hand.

With these machines there is a good saving in cost of handling charges for cupolas, having hourly capacity of ten to fifteen tons or more, the economy of operation increasing as the output

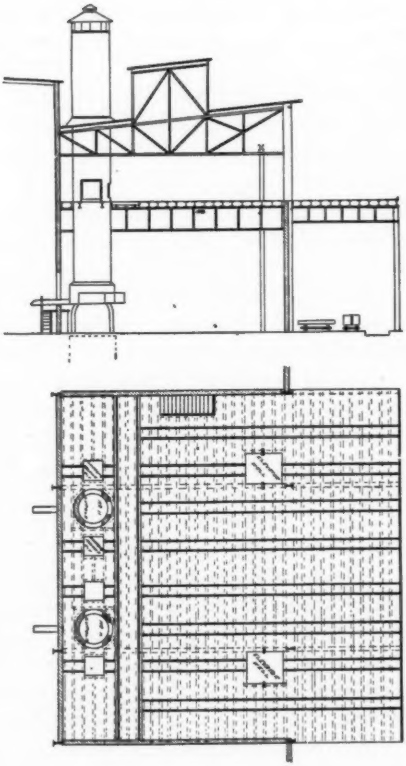


FIG. 16.—CHARGING FLOOR, GENERAL ELECTRIC CO., ERIE, PA.

per hour increases. For a No. 9½ Whiting cupola, melting 20 tons per hour, two men with charging machine attend to all charging operations, where otherwise five or six men would be required. Another advantage of this machine is, that its location is fixed in relation to the charging door, and conditions of operation are always uniform. The cost of installation is small, much less, in fact, than extra cost of cars with hinged bodies would be for any moderate-sized plant. No additional or special equipment is required in connection with charging machine. Charging cars, only, are required and they are of design that can be used for ordinary hand charging and no greater number of them is necessary.

A few diagrams showing actual layouts of charging floors and tracks may be of interest. Fig. No. 14 represents the cupola charging department of the Canada Car Co., Montreal, Quebec. There are two No. 9½ Whiting cupolas for the wheel foundry, and one No. 7 and one No. 4 cupola for the gray iron foundry. All are equipped with charging machines. The two foundries adjoin and the charging houses are connected, giving ample track space on the charging floor, and providing storage facilities below, which is desirable in that rigorous climate. The tracks on the charging floor are arranged with cross-overs so that cars may travel continuously without interference.

Fig. No. 15 shows the layout of the charging floor for the wheel foundry of the American Car and Foundry Co., at Madison, Ill. Two No. 11 Whiting cupolas are used in this foundry and both are charged by pneumatic machines. The special location of elevators was necessitated by the peculiar yard arrangement. The end elevators are used for iron; the elevator on the side for coke. Each cupola is served by the elevator nearest to it, in ordinary operation. The tracks on the charging floors have storage capacity for about seventy cars. A transfer table at each end is arranged so that a loaded car from the elevator may be transferred to any storage track; turntables in the middle provide passage from any one track to the other, and empty cars are transferred from the charging track to elevator, thus completing the circuit.

Layout of charging floor to be installed by Pennsylvania

General Electric Co. is reproduced in Fig. No. 16. This floor is served both by traveling yard crane and elevators. Transfer car makes connection with all storage tracks and with tracks to charging machine. Two No. 11 Whiting cupolas, having a capacity of 24 to 27 tons each are used, and two charging machines are furnished for each cupola.

NOTE ON THE HERAULT ELECTRIC FURNACE FOR STEEL CASTINGS AND GENERAL FOUNDRY WORK.

BY DR. P. HERAULT, PARIS, FRANCE.

At the present time some of my furnaces are busy on steel castings, in fact some are exclusively erected for that purpose; for instance, at the Fischer Steel Foundry, Schaffhausen, Switzerland; Lake & Elliot, Baintree, England, and out of forty others in operation, most of them are intermittently employed for castings, as for instance, at Worcester and South Chicago. You may judge from such castings as you may see that the steel is perfectly sound, of high quality and was good and hot when cast. It is so dead when poured that I do not need to increase the percentage of silicon, and I run 0.15 and lower.

This, however, has been proved long ago. A more interesting feature of the electric furnace is that it is capable of improving the quality of foundry iron. This at very low cost and by a very simple operation.

The main feature of what is called strong iron is the low content of sulphur. The removal of sulphur is one of the easiest and most effective operations that can be performed in the electric furnace. It consists simply in pouring into the furnace a charge of molten pig iron, if possible, direct from the blast furnace; if not, from a cupola or other melting apparatus, then heating the metal under a basic slag which does not have to be scraped or removed except when it is teemed into a ladle with the metal ready for pouring. The contents in carbon, silicon, manganese and phosphorus are not affected by this operation unless this be desired. Common Bessemer iron, worth anywhere from $10-$14 per ton, can be changed into strong iron, charcoal iron, car-wheel iron, or so-called cold-blast charcoal iron for a cost of about $1 per ton.

It seems probable that on account of the high grade of material so cheaply produced, most of the iron castings of the future will be made of this improved quality. This new improved product will help to give new life to the iron foundry industry and enable it to compete with the steel casting industry.

ON THE PREVENTION OF ACCIDENTS THROUGH FIRE.

By Thos. D. West, Cleveland, O.

At no period of the country's history has there been a greater number of reforms carried out than in the last decade Chief among these at the present moment is the struggle to safeguard life and property against the results from accidents. Among the many various accidents causing loss of life and property, there are none more to be feared than those from fire.

Foundrymen, as well as other employers, have to be on a continual lookout in this direction, for hundreds of thousands of dollars in damage, with occasional loss of life, can be directly traced to carelessness with fire. Buildings, patterns, and the equipment of many foundries have been lost, and firms entirely put out of business so often, that it would seem advisable to urge concerted action to do away with as much of this danger as may be possible. In these days of heavy and increasing accident and fire insurance rates, it becomes a question of conserving our national resources by guarding every avenue leading to life and fire losses.

It is not the purpose in this short paper to consider every factor entering into the causes of conflagrations, but to call attention to the careless use of burning matches and tobacco, as costing some fifty millions of dollars annually, not to speak of the lives sacrificed. If it were only the loss of property, we might continue to tolerate it on the supposition that it is unavoidable, but when we see almost daily, without a moment's warning, fine lives sacrificed, accompanied by horrible tortures of mind and body, a protest should go forth and steps be taken to minimize such awful risks.

The match as an originator of the damage stands unquestioned. The real reason for carelessness in its use lies in the lack of education of our youth to the responsibilities involved. Public toleration of throwing about lighted stumps, etc., on the part of children, and lighted matches, cigarettes, cigars and

burning ashes of the pipe by grown-up people who should know better, has brought things to such a pass that only the most vigorous action will awake the public conscience to the consequences of the evil.

The writer once had occasion to solicit the aid of a large journal along the line of preventing accidents. On entering the editorial rooms, he was astounded to see about a dozen men in one large room littered up with paper of all kinds. Every man in the room was smoking, and the lighted matches were being sent to the floor off and on. Here was a case of charity beginning at home.

The above instance is only what may be found in thousands of examples in our public buildings, factories, stores, shops, and places of public amusement or meeting. When the same carelessness extends to powder magazines, and coal mines, then the public press has a new disaster to herald. Similarly the recent holocaust in New York City, caused by a cigarette stump which was still alight when thrown on the floor. What practical outcome from this lesson has there been so far? No one can more thoroughly advocate the provision of every possible safety device for saving human lives in cases of emergency, than the writer, but more is needed. Since no one knows when he may be in exactly the same position and lose his life without warning or chance to escape, it behooves every one to take an active stand in the way of helping to bring about a reform along these lines.

As smoking is chiefly responsible for the careless use of matches, many firms are prohibiting the use of tobacco that way on their premises. This might be extended to compel the carrying of safety ignitors, such as the German patent device, combined with a receptacle for burning tobacco ashes on the part of those who constantly use the weed. As smoking has become part of the life of some people, there is no reason why inventive genius should not devise safety ignitors to dispense with matches and tinder boxes so compact and neat that smokers need not object to carrying them with their usual outfit. Once let such a thing be compelled by law, and an appreciable effect will be noticed in our fire losses.

It is to be hoped that the agitation of this important subject may lead to some substantial results in the way of saving

life and property, and that foundrymen, as well as the general public, will awaken to their duties in this regard. Only by awakening a strong public sentiment, and this leading to legislation with subsequent enforcement of the law, will good come of the movement, and lives and property will be more safe than heretofore.

VANADIUM IN IRON AND STEEL CASTINGS.

By G. L. Norris, Pittsburgh, Pa.

The use of vanadium in gray iron castings has been limited when compared to its use in steel castings, although the past year has shown a marked increase, and its use in certain classes of castings has become well established. In the case of steel, we have a refined metal with certain physical properties not possessed by cast iron, and susceptible of improvement by heat treatment. In the case of cast iron we have a material that has undergone very little or no refinement, and is only slightly different from the crude pig iron from which it was produced. Its only metallurgical treatment is usually a simple melting operation with or without scrap cast iron and steel.

Undoubtedly the greater portion of the iron castings made to-day are satisfactory, so far as the quality of the iron is concerned, to meet the requirements for which they were designed, although a large percentage could, with advantage, be greatly improved in quality.

We have then, in the case of cast iron, a material, the cost of producing which, from the crude pig iron, has been slight. The price at which iron castings in general are sold precludes the use of any alloy for affecting the quality of the material, that will increase the cost materially, excepting in the case of certain classes of castings where unusual strength or some special quality in the iron is desired. In such cases even a very material increase in the cost of the castings is readily accepted.

In the case of vanadium we are dealing with a metal of fairly high price, and its use in the manufacture of cast iron naturally will be confined to the classes of work that can stand a material increase in cost in return for the special qualities obtained. The addition of 1/10 per cent. of vanadium to cast iron, at the present price of $5.00 per pound, means an increase of ½ cent a pound for the iron in the ladle, and necessitates an increase in selling price of ¾ cent to 1 cent a pound at least to cover losses due to scrap, gates, sprues, etc.

I am mentioning these points not for the purpose of discouraging the use of vanadium in cast iron, but because of frequent inquiries which show that they are not thoroughly understood. Some of these inquiries indicate a belief that vanadium is a panacea for all foundry troubles including cold melted iron.

Vanadium has been applied to cast iron with great success for certain purposes and the results obtained indicate its effective application in other lines.

While vanadium has a strong affinity for oxygen and nitrogen and is partly used up by combining with these elements, the primary purpose of adding vanadium to cast iron is not the removal of oxygen and nitrogen. The removal of oxygen can be effected sufficiently well by cheaper means, and as the injurious effect of small amounts of nitrogen on a refined metal, such as steel, is still an open question, the harmfulness of this element on a metallurgically crude metal like cast iron is open to still greater doubt.

The object of the use of vanadium in cast iron, then, is to give certain qualities to the iron, and to do this the vanadium must enter into the cast iron as a component part.

Vanadium increases the strength of the cast iron to which it is added from 10 to 25 per cent., depending, of course, upon the initial strength of the iron. This increase of strength is due directly to the intensifying effect of the vanadium on the metals present in the cast iron alloy, such as silicon and manganese, and also by combination with the chemically combined carbon.

It exercises a very strong effect on the grain of the iron, causing a more even distribution of the graphite with consequent greater freedom from both hard and porous spots. This effect is very apparent, vanadium cast iron fractures showing a finer and more uniform grain. In the case of chilled iron, vanadium produces a deeper, stronger and tougher chill, and one less liable to spall or flake. This chill, however, is not as hard apparently as the more brittle chill of ordinary chilling iron, and can be filed and machined more readily. Vanadium also gives an element of toughness to cast iron, which is very apparent in machining the castings. This toughening effect, together with the uniform fineness of grain or texture due to even distribution of graphite in small flakes, makes vanadium

cast iron very superior for such purposes as gas and steam-engine cylinders, valve and piston bushings, piston rings, glass bottle molds, gears, castings to withstand heat and internal pressures of fluids and gases without leakage.

Three or four years ago the New York Central lines equipped one of its locomotives with a pair of cast iron cylinders containing vanadium. The performance of this pair of cylinders over a test period of about two years was so satisfactory that 500 or more locomotives on these lines are now equipped with similar cylinders. The test of the original pair demonstrated that over twice the normal mileage of ordinary cast iron cylinders could be obtained from such cylinders before reboring. The loss in casting these cylinders was extremely low, no cylinders being scrapped at all for the first 183 locomotives ordered. The same sort of results have been reported by a builder of large gasoline engines for marine use. In this particular case, the number of cylinders formerly lost when tested after machining, was excessive, due to porousness of certain sections.

Piston rings and cylinder and valve bushings of cast iron with vanadium have been thoroughly tried out and adopted by a number of leading railroads on account of the greatly increased length of service obtained. A very interesting application of vanadium has been for glass bottle molds. These, as you are well aware, are chill castings, and are usually covered with engraving. The iron has to be clean, close and uniform in grain, machineable, and take a good polish. The first cast iron bottle molds of this kind were made a little over a year ago and proved not only to have a longer life, but it was found possible to increase the speed of the bottle machines, as the glass did not appear to stick to these molds to any extent. This can be readily accounted for by the uniformity of the grain and freedom from mottled spots.

One of the first applications of vanadium to cast iron, was in chilled iron rolls for sheet mills. A number of these were made and gave excellent results, some of them showing 50 per cent. greater tonnage with one-half the dressing against the regular chilled roll. The question of cost, however, entered in here in an unusual manner. Fully 65 to 70 per cent. of the roll breakages are due to accidental causes and no amount of vana-

dium would insure, for instance, against a roller letting a pair of tongs pass through the rolls.

We have had opportunity, from time to time, to make comparative tests of the strength of cast iron with and without vanadium, extending over a considerable period, and believe that these comparisons are more nearly representative than single tests, as they represent average conditions.

The following tests are the average for ten consecutive days' work on locomotive cylinders. The transverse tests were made on bars 1 inch square, 12 inches between supports; the bars were machined all over and consequently were absolutely comparable, which is not always the case with bars only brushed or cleaned.

	Transverse	Tensile
Plain Cast Iron	2,130 lbs.	24,225 lbs.
Cast Iron with Vanadium	2,318 lbs.	28,728 lbs.

This iron has stood 750 pounds water pressure for sections ¾ inch thick. The average chemical analysis of this iron is about as follows:

Combined carbon	.50
Silicon	1.50
Manganese	.45
Phosphorus	.600
Sulphur	.095

I endeavored to get together for this convention a series of tests on irons of various compositions, to show the effect of vanadium both on the strength and on the chilling qualities, but owing to various delays, I am not able to present this in complete form. The following tests were supposed to be from iron from the same ladle, before and after adding vanadium, but the chemical analysis shows that such could not have been the case. The difference in composition, however, so far as it influences the physical qualities of the iron, are all in favor of the iron without vanadium. In addition to the bars for tensile test, chill blocks were cast to show the effect of vanadium on the depth of the chill.

CHEMICAL COMPOSITION.

	Without Vanadium	With Vanadium
Graphitic carbon	2.34	2.48
Combined carbon	.79	.71
Silicon	1.83	2.21
Manganese	.43	.424
Phosphorus	.508	.546
Sulphur	.102	.071
Vanadium	...	.056

PHYSICAL TESTS.

	Without Vanadium	With Vanadium
Tensile strength	34,560	35,600
Depth of chill	no white chill	1/16 in. white chill

Size of chill test block 4½ inches square by 1½ inches thick.

The difference in machining quality of the two irons was decidedly in favor of that containing vanadium. I need hardly mention that the cast iron treated with vanadium should be at least approximately of the proper composition for the particular class of work to which it is intended.

The usual amount of vanadium added to cast iron is 1/10 per cent. for cupola melted iron, equivalent to about 5 ounces of ferro-vanadium for each 100 pounds. Some foundries advocate the use of a higher percentage, up to 15 per cent., which is about as much as can be conveniently added in the ladle. As low a percentage as .05 per cent. will produce distinctive effects. Owing to the high melting point of vanadium and the limited reserve heat available in a ladle of iron, it is advisable to use the alloy in a finely crushed condition, or even powdered, when the amount of iron treated is small, and to use an alloy of low melting point. The iron should be tapped out as hot as possible and a ladle used that has just been emptied in order to conserve as much heat as possible. After the bottom of the ladle is covered with a few inches of iron, the finely crushed or powdered ferro-vanadium is added by sprinkling on the stream as it flows

down the spout to the ladle; in this way advantage is taken of all the available heat and also of the mixing effect of the stream as it strikes the iron in the ladle. After the vanadium is added, the contents of the ladle should be well stirred and allowed to stand a few moments in order to insure thorough incorporation and complete reaction.

In the case of the higher grade air furnace iron, with its reserve of available furnace heat, the procedure is very simple; after the charge is melted, and 15 to 20 minutes before tapping, the ferro-vanadium is added and the bath well stirred or rabbled. The addition of .18 to .20 per cent. vanadium is recommended in this case, equivalent to 10 to 11 ounces of 35 per cent. ferro-vanadium per 100 pounds of metal.

The American Vanadium Company has lately developed a ferro-vanadium containing about 30 per cent. to 35 per cent. vanadium, 10 per cent. to 15 per cent. silicon, 5 per cent. to 10 per cent. manganese and 2 per cent. to 5 per cent. aluminum, which melts and dissolves readily in molten cast iron, and has been giving very satisfactory results.

In the case of steel castings, unlike cast iron, we have a homogeneous, refined metal of a high degree of purity, strength and ductility, and peculiarly susceptible to the influence of alloying metals. Steel castings have replaced iron castings for many purposes, the greater strength combined with ductility making it possible to effect great savings in weight. Steel castings have also been substituted for many forged parts, one notable instance being locomotive frames, and are not only subject to static but dynamic stresses. The failures of steel castings have undoubtedly been largely due to their lack of dynamic strength or ability to withstand repeated stresses. These failures are attributed to fatigue and crystallization of the steel.

The effect of vanadium in plain carbon steel castings is to increase the elastic limit about 30 per cent., giving a much higher proportion of available strength for the same ultimate strength. In addition, the vanadium increases the dynamic strength or power to withstand repeated and alternating stresses, fully 50 per cent. I would emphasize here, again, the fact that it is the effect of vanadium as a component part of the steel that is particularly desired, and not the scavenging or cleansing

properties. One purpose of calling attention emphatically to this is because from time to time, one hears of unfavorable reports of vanadium steel, which upon examination proved to contain none of this element, the explanation given the purchaser being that the property of vanadium was solely that of a scavenger and it was not essential that any remain in the steel.

Prof. Arnold, of Sheffield, is of the opinion that vanadium is undoubtedly the element which, together with carbon, acts with the greatest intensity in the way of improving alloys of iron, that is to say, in very small percentages, and Prof. Arnold was also of the opinion that vanadium has not only a chemical, but also a physical influence in promoting the even distribution of the carbon and retarding constitutional segregation.

One of the earliest applications of vanadium steel was for locomotive frame castings. For years these frames had been made of hammered wrought iron. Then with the advent of steel castings this material became commonly used. With the great increase in size and weight of locomotives in recent years, the increasing failures of frames became a very serious matter. The great increase in elastic limit and resistance to repeated stresses, possible by the addition of a small percentage of vanadium to steel castings, at once appealed to the motive power men. Trial frames were put to test under locomotives that had records as chronic frame breakers, and with such remarkable freedom from failures that a number of roads immediately adopted cast steel frames with vanadium as standard. There are now in the neighborhood of 1,500 frames in service and the known failures are insignificant, less than half a dozen.

The following comparative tests from plain carbon and cast steel frames with vanadium in them show very clearly the effect of vanadium. The steels were made by the same concern, from the same character of stock.

CHEMICAL COMPOSITION.

No.	Carbon	Phosphorus	Manganese	Sulphur	Silicon	Vanadium
8875	.25	.036	.60	.024	.23	none
9215	.235	.047	.575	.030	.25	.185

PHYSICAL TESTS.

No.	Elastic Limit	Ultimate Strength	Elongation % in 2 in.	Reduction of area.
8875	37160	71700	33.0	48.2
8875	36710	70180	31.5	52.8
9215	45660	76620	27.5	51.1
9215	42590	78200	31.0	51.8

8875 Alternating impact ¼ inch throw—average 1918
9215 Alternating impact ¼ inch throw—average 2952

The alternating impact tests are made on a bar ⅜ inch diameter and effective test strength 4 inches; the bar is held in a vise and the free end moves rapidly back and forth by means of a slotted hammer. In the case of the above tests, the rate of alternations was about 600 per minute, and the movement was ¼ inch either way from the normal position, or a total movement of ½ inch.

Steel castings containing vanadium should never be used without annealing. In the unannealed state they are more brittle than plain carbon steel castings. In annealing it is found that such castings require a somewhat higher temperature than ordinary steel castings. For locomotive castings and similar work, a temperature of at least 1,500° F. is required, and preferably 1,560° F.

Vanadium steel has been used in a great variety of castings, especially those subjected to repeated stresses and wear. It would be useless to attempt to enumerate them all, but I would call attention to two classes of castings that are giving remarkable results. These are rolling mill pinions and gears and automobile castings. Rolling mill pinions have shown two to three times the life of carbon steel pinions and one and a half to two and a half times the life of nickel steel pinions.

While I would not want to recommend the replacement of drop forgings by any steel castings in the construction of an automobile, yet the record of castings of vanadium steel in certain automobiles has been remarkable.

These are made regularly by all the various steel making processes, and present no particular difficulty. The principal requirement being to have the steel clean and free from oxides,

and the slag in proper condition in the case of open-hearth steel. The cleansing of the steel from oxides by manganese and silicon is a well understood operation and need not be gone into here in detail. The vanadium in the form of ferro-vanadium should be the last addition made, and a little time allowed after the addition of manganese and silicon for these elements to react.

In the case of crucible steel castings, the general practice is to add the ferro-vanadium to the crucible with the mix, and melt down. The amount of vanadium that has been found most satisfactory to add is .25 per cent., or 2½ pounds to each 1,000 pounds of steel. The amount of vanadium remaining in the steel from this addition is usually .18 to .20 per cent. In the case of crucible and acid open-hearth steel the scrap should be saved, as in remelting a considerable portion, about 20 to 25 per cent. of the vanadium, is not lost, and advantage should be taken of this fact. Tests of the high silicon, high manganese ferro-vanadium already referred to have demonstrated that it is more economical to use, as the silicon and manganese apparently exercise a sort of protecting influence and enable a larger amount of the vanadium to enter into the steel.

The field of application for vanadium in bearing metals has recently been receiving considerable attention, and already some very interesting results have been obtained. One of the most notable of these has been the performance of a vanadium bronze bearing metal in a step bearing of a grinding machine. The load on the bearing of this machine ranges between 1,000 and 1,100 pounds per square inch, and the great difficulty heretofore has been to secure a metal that would stand up under this pressure, and give satisfactory results with regard to wear and friction. A number of bearing metals of high reputation have been tried out under this machine and some of them have only lasted fifteen to sixteen hours. The vanadium bronze bearing metal tested out was based on the standard P. R. R. car box bronze mixture, with the addition of about .05 per cent. vanadium. Bearings from this mixture have been in service for a year with entire satisfaction. The amount of wear on these bearings has been very small, and, as a matter of fact, the operators of the machines have been unwilling to have the bearings taken out for measurement as they are entirely satisfied with their performance.

As a result of the very satisfactory performance of these bearings, the mechanical department of this same works has recently started tests of standard babbitt metal with the addition of a small quantity of vanadium. This babbitt has only been in service about a month in electric motors, but it is showing up very satisfactory and promises to prove superior to the standard babbitt.

BRIQUETTING METAL BORINGS.

By Dr. Richard Moldenke, Watchung, N. J.

One of the latest developments in the metal industry in connection with the utilization of metallic waste is the process of briquetting it under enormous pressure, without the use of a binding medium.

The process in question was originated by Arpad Ronay, of Buda Pesth, who conceived the idea of imitating nature as closely as possible in the production of rock deposits. That is to say, he combined extreme pressure with a sufficiency of time to allow individual particles to get close together, excluding thereby spaces filled with air or water, which under the pressure in question would tend to weaken the bond. This is exactly what happens in nature in the formation of deposits, the very fine particles of disintegrated minerals settling down slowly and into close contact, to be later on compressed into stone by the weight of superposed layers.

When metal particles, as well as ores or other fine materials, are subjected to the ordinary rapid and heavy pressures, enough air is entrained to give trouble when the briquettes are heated up. The air expands, causing the breaking up of the briquette with consequent excessive loss and troubles incident to the use of the fine material untreated. Ronay's results were surprising in that the briquettes when properly made, allowing this entrained air to escape, were perfectly inert so far as their integrity was concerned. Ore briquettes were reduced like regular lump ore, while metal briquettes melted like pig iron. It is this treatment that forms the basis of the patent protection.

When the writer was first asked to investigate the process professionally at the instance of American interests, before going to Europe to do so, he took one of the German briquettes made of cast borings, and melted it in his cupola, leaving the breast open, so that by means of an iron bar, contact could be had with the briquette from time to time, as it melted. It was found that the lump of briquetted borings melted just as a piece of pig iron

FIG I.

would, holding its shape until the final softening and dropping to the bottom.

A visit to the several briquetting installations in Europe existing at the time, showed the briquetting industry to be in a flourishing condition, and since that time more plants have been

FIG. 2.

added, making 14 in number at this writing. They are in Berlin, Chemnitz, Stolberg, Cassel, and at the Imperial Navy Yard at Kiel. Then there are plants in Vienna, Buda Pesth, Milan, Prague, and Bruenn at Winterthuer, Switzerland; illustrations of some of the machines used and one of the early

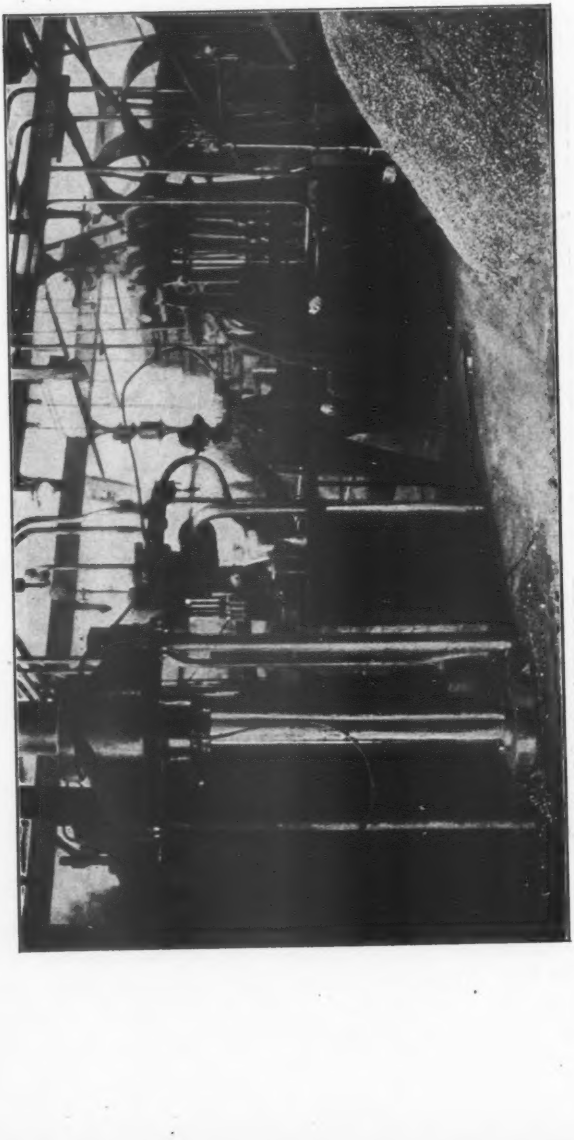


FIG. 3.

plants will follow. In this country the process is operated by the Metal Briquetting Co., of New York City.

In general, the process may be described as follows: Cast iron, steel, brass, bronze, aluminum, copper chips, borings, filings, and metallic slimes after drying, and for that matter sawdust, coal, graphite, salt, ore, flue dust, etc., go to a hopper above the press proper. In the case of borings, it is first necessary to allow these to pass by an exhaust fan, to remove dust and dirt (also taking the very fine graphite away, which cannot be avoided when cleaning thus). Incidentally, where there has been some slight rusting of the borings, the rubbing of the particles upon each other during transit, loosens the rust, and this is drawn away by the exhaust, thereby greatly improving the quality of the briquette, as rust is never a good thing to go into the cupola.

In the case of steel turnings, these pass through a set of disintegrating rolls in order to reduce bulk.

After cleaning the borings by exhausting the dirt and sweepings, they pass over an electro-magnetic separator, to remove brass from iron. The cleaned and separated borings now pass into the feed hopper of the press. Fig. 1 shows such a machine as used at the original Chemnitz plant. The bunker is filled with borings from the bucket elevator shown at the right. The borings flow by gravity into the hopper of the press, then into the die, and as the plunger descends, receive their first compression. The air passes out as the borings go together, the separate particles curl into each other, and the partially completed briquette, in the die, passes on carried by the revolving press table to the next stop where plungers below and above apply pressure up to 35,000 pounds per square inch. The die containing the briquette is free to move up or down at this point, giving the compressed material within freedom to adjust itself to an evenly distributed force.

On the withdrawal of the plungers, the revolving table makes another movement, placing the die with the finished briquette within (slightly conical in shape) under another plunger, which forces the briquette out and upon a band to take it away from the machine. All these movements are entirely automatic,

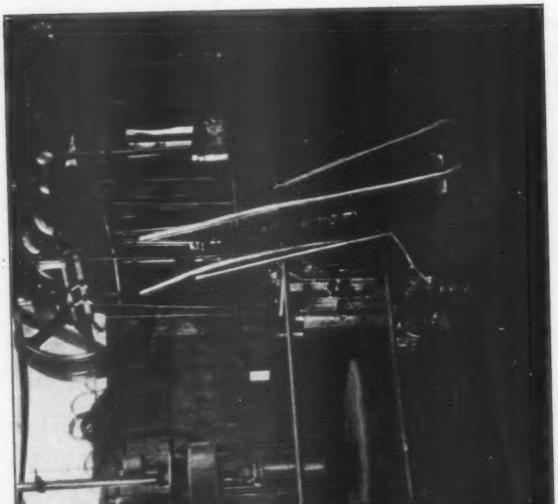


FIG. 4.

FIG. 5.

the valve regulation being perfect, one man looking after the operation of the press itself, another taking the briquettes away, while a third sees that the hoppers are properly fed from borings received at the plant. A foreman machinist looks after the

FIG. 6.

general operations, the pumps, accumulator and intensifying units.

It may be interesting to state that the briquettes, after leaving the press, become quite hot, so that any oil originally in the

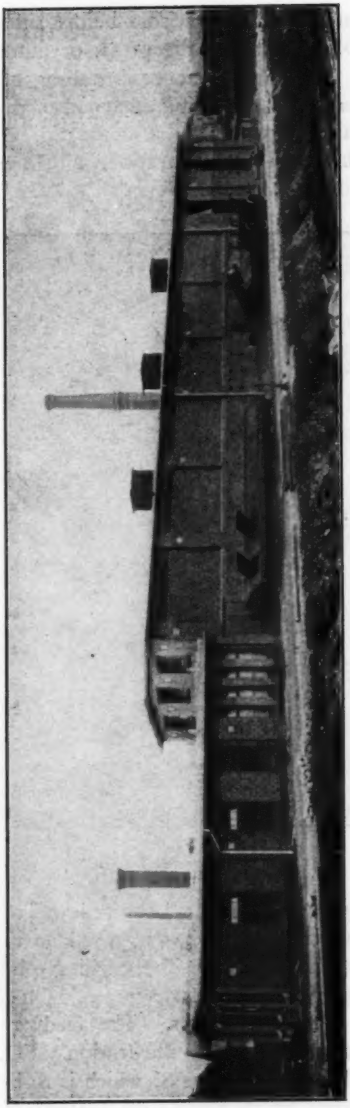


FIG. 7.

borings, and that applied to the die before filling either by a swab in hands of the man at the press, or automatically, does some smoking. Moisture present also disappears in a short while, the heat, however, not being sufficient to prevent the hand from resting on the briquettes for a moment.

The press shown in the illustration, with a capacity of 1½ tons an hour, and hence one of the small sizes, is running regu-

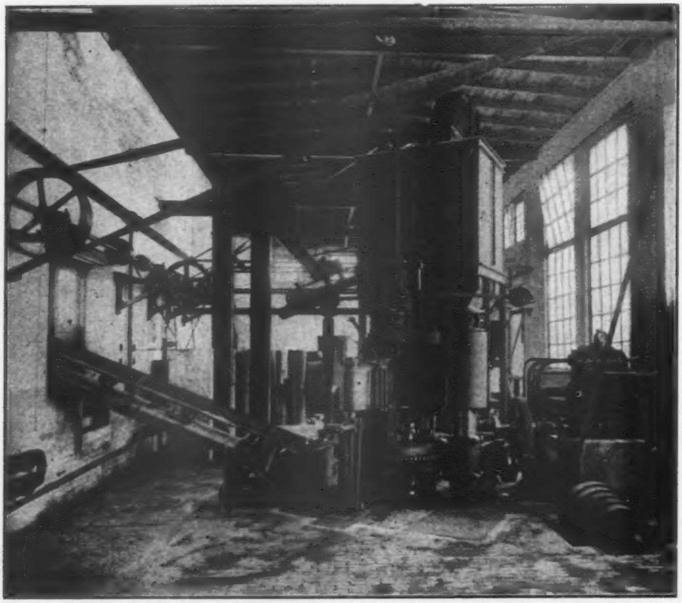


FIG. 8.

larly for several years, and beyond the renewal of the cast iron dies every three months or so, has required no repairs. Fig. 2 shows the feeding hopper with the packing plunger working through it, on the right side of the press. On the left is the counter-weighted ejecting plunger. The feeding bunker is on the upper right hand side of the illustration. Fig. 3 shows the intensifier, at the left, the purpose of which is to bring the water pressure of the very heavy pumps up to that of some 35,000

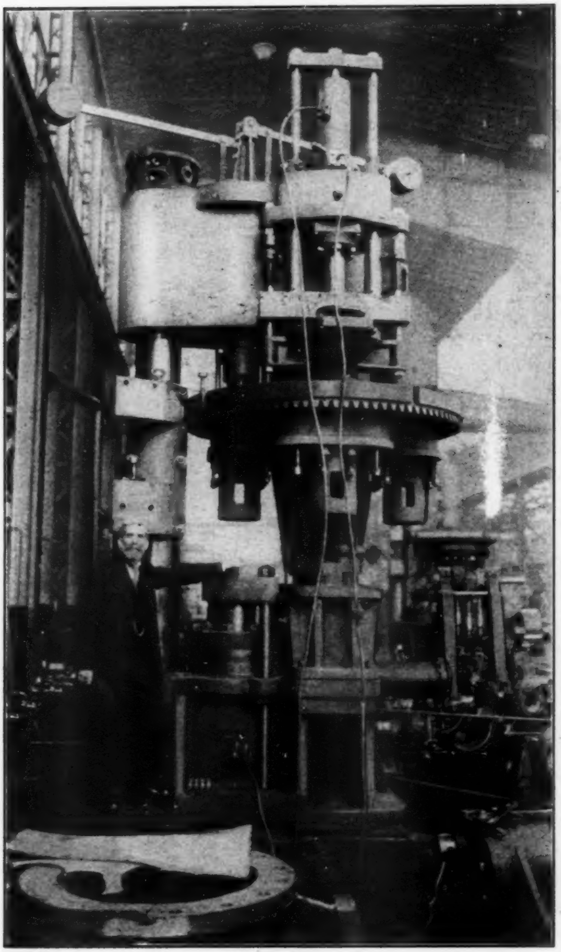


FIG. 9.

FIG. 10.

pounds per square inch as required for the work in hand. The larger cylinder of the intensifier is below the floor line. At the right of the illustration are two pumps for obtaining the necessary primary pressures, and in the lower right hand corner will be

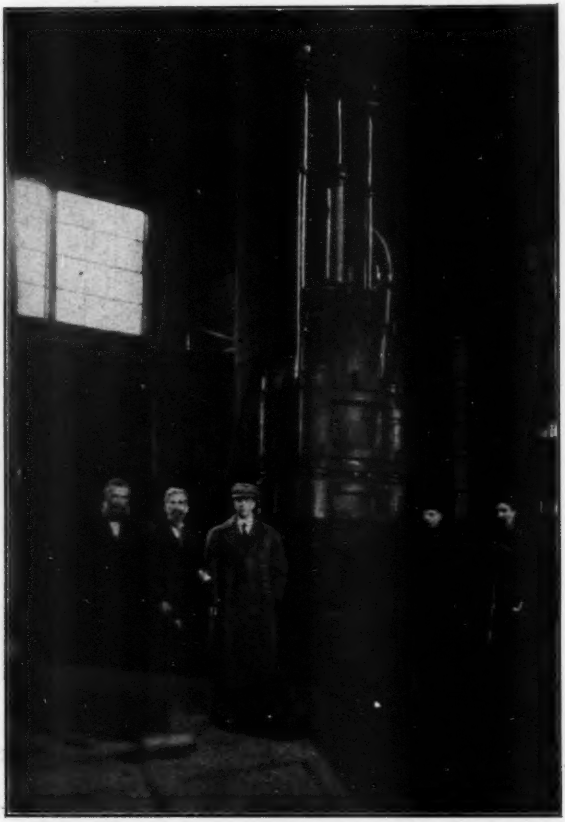


FIG. 11.

seen some cast iron chip briquettes. Fig. 4 shows the accumulators, always necessary in hydraulic plants to insure even working and rapid action. This plant has two sets of pumps, accumulators and intensifiers, only one of which was in use, the other

being in reserve. The large pump is shown in the right hand side of the illustration.

While discussing this particular plant, it will be of interest to note the pile of cast iron briquettes shown in Fig. 5. These briquettes are 6¼ inches in diameter, and 7 inches high, weighing 38 pounds each. Fig. 6 shows a pile of wrought iron chip

FIG. 12.

briquettes, of a shape no longer used. The round briquettes—the present form—are seen at the right.

This Chemnitz plant has since been removed into a new building, the exterior of which is shown in Fig. 7. There may be noted the bins for unloading shipments of borings separately, so that the product of a works may not be mixed together with that of another establishment. The loading conveyor is also shown, by means of which briquettes are sent from the press automatically on cars, without any handling whatever.

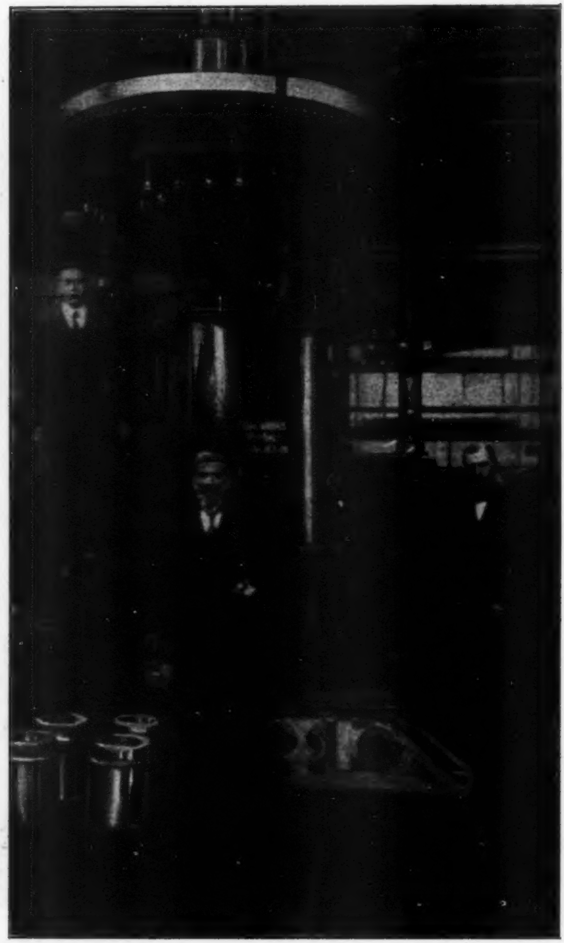


FIG. 13.

Fig. 8 shows the interior of the plant with one of the new large presses installed—the old one from the other plant not having been placed at the time the picture was taken, being too busy to move until the new press cared for its daily burden.

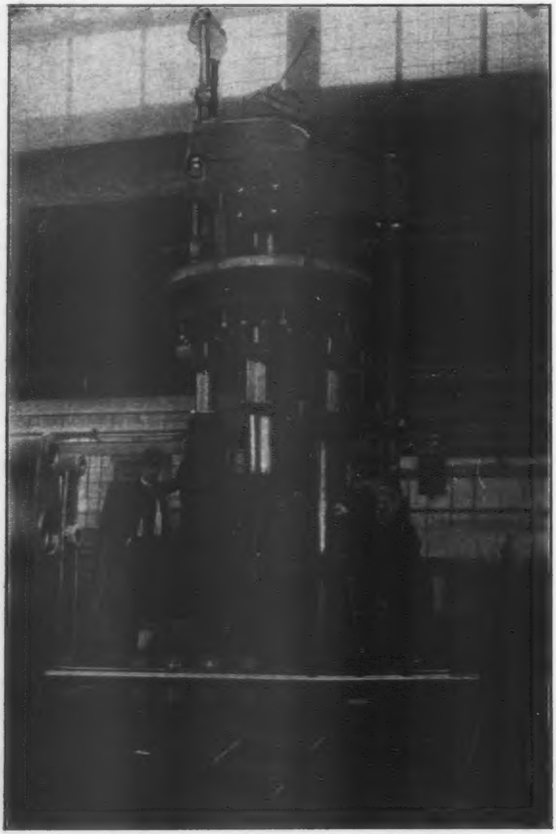


FIG. 14.

This new press is of 6 tons per hour capacity, and automatic in every particular, thus reducing the cost of briquetting—including overhead charges, interest, labor and all—exclusive of royalty, however—to about fifty cents a ton. The cost of such a

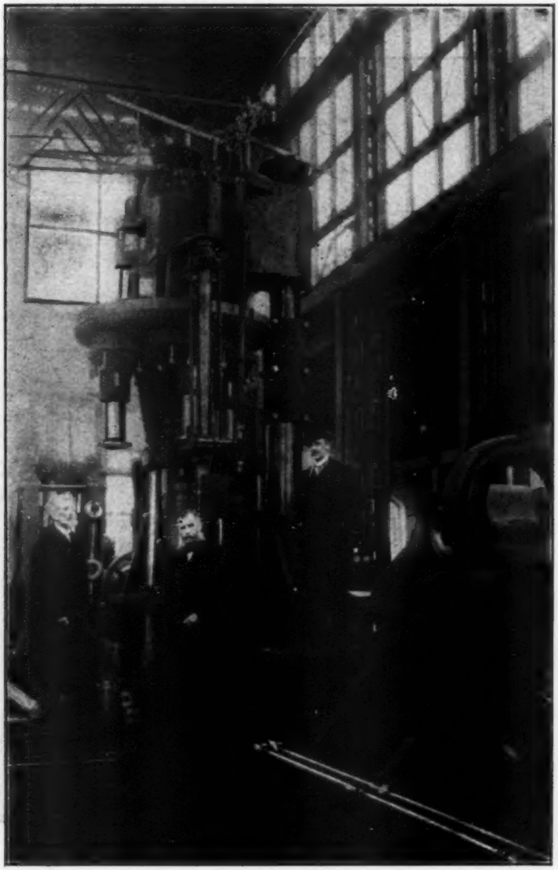


FIG. 15.

large press, with conveying apparatus and all accessories, is about $35,000, which shows to what perfection the process has been brought in Europe in the short time the matter has been before the iron industry.

Fig. 9 shows this big press while under construction at the

FIG. 16.

great locomotive works of A. Borsig, in Tegel, Berlin. The upper front shows the feeding hopper and packing plunger. Mr. Wm. Lorenz, of Hartford, Conn., representing the interests for whom the writer went to Europe, and who had all the photo-

graphs shown in this paper taken, has his hand on the pressing piston. The counter plunger is over this, above the turntable. The shaft behind Mr. Lorenz, and the central shaft, are tie rods to bear the reactive thrust during the pressing operation. The vertical rod attached to the pressing piston is one of a pair of rods connecting it with another piston below, arranged for withdrawing the pressing piston after it has made its stroke. The machine, as shown, was then practically completed. As this press is one of the latest, a mold lubricating mechanism is shown in the upper front of Fig. 10, which also has the briquette removing apparatus on the right side of the press.

As a bit of contrast, Fig. 11 shows the oldest press, in operation daily at the Borsig plant. The piston is up, and in the operation by a suitable valve mechanism, the several pressures are applied successively by the same plunger. Under the shovel held by one of the men is a sheet iron cup used for filling the mold with chips. At the right is a pile of chips. In the middle a pile of briquettes. Fig. 12 shows the piston down. At the left stands Mr. Lorenz, the writer, and Mr. Ronay, the inventor of the system.

Fig. 13 shows a 5-ton an hour press for the new Berlin works. It is not entirely assembled. Part of the briquette removing mechanism is shown at the right. The ejecting plunger is just to the left of this. The four molds are shown in the lower left hand corner. Fig. 14 shows the press completely assembled with the exception of the mold lubricator. Mr. Ronay stands on the left. Fig. 15 was taken from the ejection side. Fig. 16 shows two molds and one plunger end belonging to this Berlin press, and Fig. 17 shows three completed intensifiers. Mr. Lorenz is standing beside a pump frame. To the right is a completed pump for the Chemnitz plant—which, by the way, is built large enough to hold a series of these presses.

The perfecting of these presses has cost probably two hundred thousand dollars and the unremitting attention of several years. Hence, the state of perfection achieved, as well as the lesson learned that working out new hydraulic methods is very costly, especially when dealing with the enormous pressures in question. As a consequence, however, of the study of the minutiae of the process a marvelous economy has been effected,

FIG. 17.

as any one who will try the plan on existing presses in comparison will testify to when he gets tired of the expense.

Fig. 18 illustrates the cast borings briquette, showing how perfect it comes from the press. The briquettes are so uniform

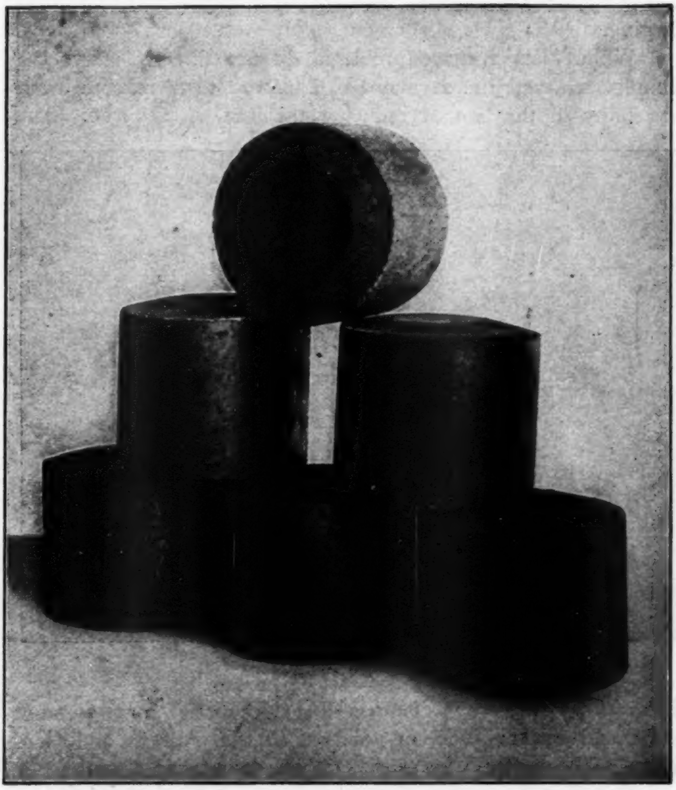


FIG. 18.

in weight that counting them while charging is sufficient for all purposes. Fig. 19 shows a pile of these briquettes at the Borsig works, Berlin, and indicates that they can be handled just like pig iron. In fact they have been piled twice as high, transported everywhere in open or covered cars, without any dam-

age whatever, and when charged into the cupola, melt without disintegrating.

As an interesting sidelight, Fig. 20 shows what can be done with a briquette of wrought iron borings. This was heated up and put under the hammer, turning out a very serviceable drop-forging.

While blast furnace problems do not directly affect the foundrymen, yet Fig. 21 may be of interest to them, showing a possibility in the line of reducing the cost of pig iron. The

FIG. 19.

illustration shows the famous Friedenshuette furnace—now rather old—at the junction point of Russia, Austria and Germany. The writer was present at the time, and saw the ore and flue dust briquettes charged into the bell of the furnace, and pieces of the lining at the hearth taken away in repair, which had portions of a briquette adhering to it partly fused at one end and the other intact, showing that the briquette went down the entire length of the furnace without disintegrating. Considering the enormous amount of flue dust dumped on the waste piles in this country, here is a chance for economy.

What will naturally interest foundrymen most is the behavior of briquettes in the cupola. Fig. 22 shows how these briquettes are charged at the Borsig works in Berlin. The smoke and dust as well as darkness on the charging platform account for the poor illustration. The writer saw this heat personally and took special note of the castings made at the time. He also saw a number of cast and other borings briquettes which had been partially melted and had their shape otherwise intact, these

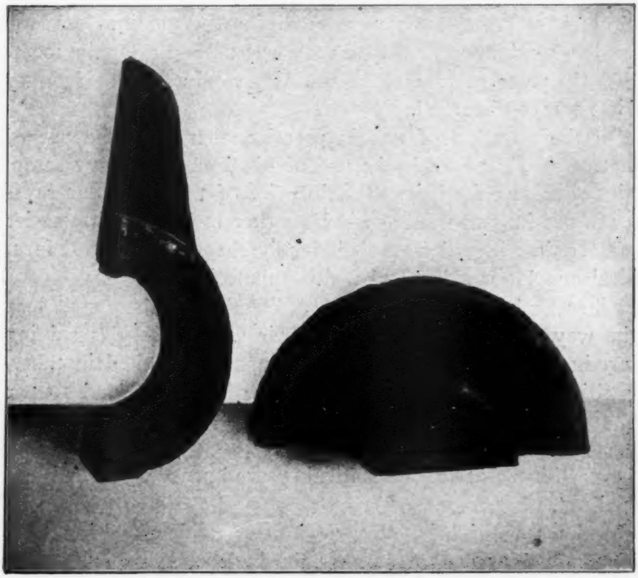


FIG. 20.

being recovered on dropping bottom specially before the respective heats had been completed.

The use of borings in the cupola is an affair probably as old as the cupola itself. Until very recent times, however, but little of value has resulted in this direction. Whitney and Outerbridge were the first to give results to the public, and in the days of high-priced iron, boxing up the borings in wooden containers answered fairly well. Then, again, in the anthracite

region it was a common thing to use old powder cans, nearly filled up with borings, the tops beated down, and the canisters charged into the cupola. Latterly, an adaptation of this with the novel feature of continuous tubes filled with the borings has met with considerable success when carefully handled. All these methods, however, may be described as "fussy," even if effective, one works using all the old cans that could be obtained until the supply gave out. With the briquetting method, however, which aside from the royalty question, is the cheapest of them all, a new era was commenced, for the melting loss was reduced to a minimum, no apparatus was needed after the material left the press room, and the ordinary conduct of the foundry was in no way disturbed.

On the question of cupola practice, therefore, the use of briquettes simply parallels the use of pig iron and heavy scrap, and inasmuch as the briquettes, in spite of the enormous pressure, are not fully as solid as pig iron, they melt somewhat easier and faster than it, and from their handy shape and weight, form an ideal cupola charging and melting material.

Whereas, borings when charged directly into the cupola lose all the way up to 50 per cent. of their weight, besides ruining the product; when they are boxed, canned, or melted in tubes, the melting loss is not excessive, varying between 8 and 12 per cent., the danger always remaining that the cans or tubes will open, and by discharging the loose borings over the coke bed, ruin everything that follows until they are burned or melted and washed out.

In the case of briquettes, as in every other melting tests made to get figures on a process, much depends upon how the melting is done. For instance, in melting straight pig iron with small precautions to get the very best melting practice, the melting loss may amount to 3 per cent. and even over. Where, however, these precautions are taken, repeated tests have made this loss about 1 per cent., and in the case of sandless pig, as low as 0.3 per cent.—some carbon having probably been taken up during the melt. Hence, also in the case of running straight heats of briquettes, the melting loss with practice that gave 2.5 to 3 per cent. loss for straight pig iron, gave 8 to 10 per cent. for the briquette loss. With careful practice, however, there is no difficulty in getting this down to 6 per cent.

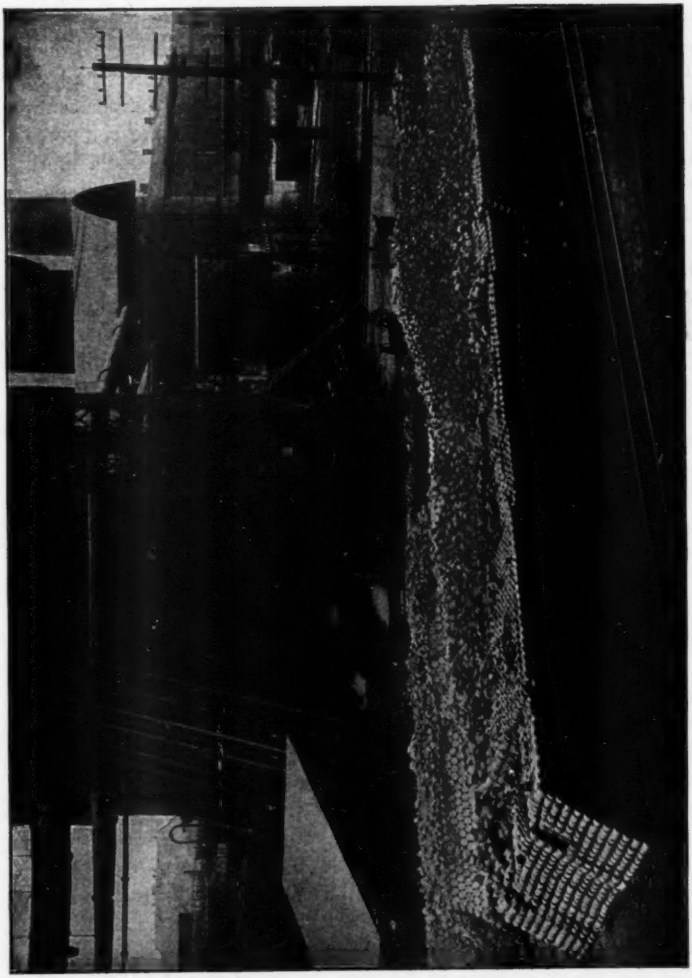


FIG. 21.

As, however, no one would think of running a straight heat of briquettes for daily practice, but charge all the way from 10 to 80 per cent. of these articles, the rest being pig iron and shop scrap, the melting loss of the heat will be about the normal one. In the case of a heat made with 80 per cent. briquettes and 20 per cent. pig iron, the actual melting loss was only 3.5 per cent., showing either more careful practice, or else that the comparatively heavy pig iron held the temperatures in the cupola more sharply localized, doing the melting where wanted without oxidizing what was above.

In the calculation of expense when using briquettes—inasmuch as these would form but part of a charge—the factor of extra loss from melting them can be altogether neglected.

There are some metallurgical changes in melting borings, whether loose or briquetted, which must be reckoned with. In melting a material which has such an enormous surface for a given weight, and which even when compressed practically solid to remove the disadvantages of the disproportion in question, can still be permeated by gases to some extent when expanded by heat, certain changes necessarily take place. The silicon will be lowered considerably more than is the case ordinarily; similarly the total carbon, while the sulphur taken up is about double the ordinary increase. This, of course, is particularly noticeable only when an entire heat of briquettes is to be reckoned with. Under ordinary conditions, with part briquettes only, there is little difference noticeable, and for such work as cylinders of gas and steam engines, ammonia castings and the like, there is a marked improvement on the part of the castings produced. This may be understood more readily by remembering the fact that a reduction in the total carbon and silicon corresponds to a steel addition to the charge. The slight increase in sulphur means a structure more finely granular, and hence a better wearing surface for cylinder work. Inasmuch as the large locomotive works of the continent are adopting the use of briquettes, and when proper melting practice prevails, the castings made are perfectly sound and free from blow and pin holes, it is evident that the use of borings in the way described is not a detriment. In fact, strange as it may seem, in Germany these briquettes are actually sold at pig iron prices, and at the Borsig works, for

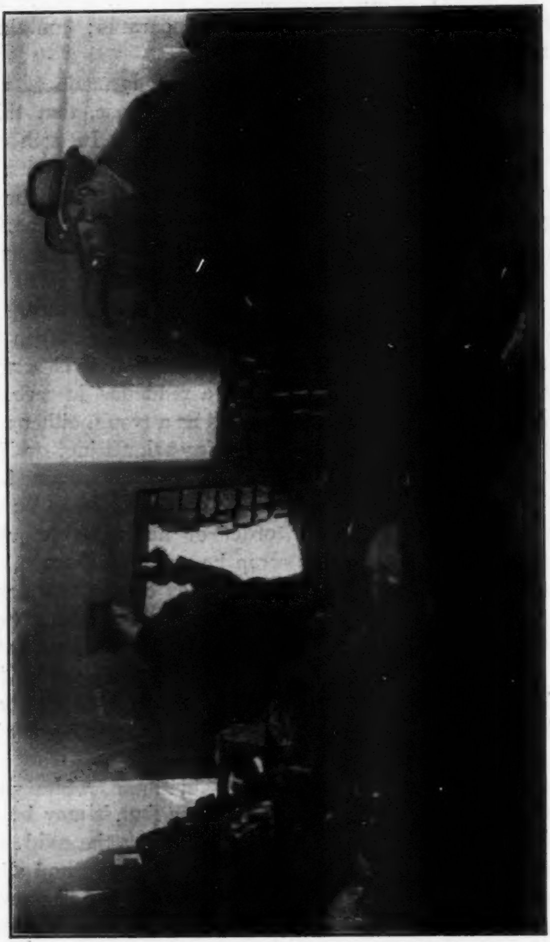


FIG. 22.

instance, the regular charges for steam and gas engine cylinders, and other engine parts; refrigerating machinery (ammonia and sulphurous acid); hydraulic machinery and air compressors; superheated steam and steam turbine apparatus; contain 40 per cent. of briquettes.

Be it noted further, that when mention is made of extra silicon and carbon removal, and sulphur increase, that this is more noticeable with imperfect cupola practice. In such cases even the ordinary run of work will show abnormal results.

Perhaps one of the most interesting applications of the briquetting process lies in the ability to mix steel with cast borings. Here is a most excellent way of charging steel into the cupola without burning up a portion of it before melting. The contact of a low carbon with a high carbon material means the melting down of this combination with an average carbon content. In place, therefore, of adding 40 per cent. steel scrap to the charge and in melting, get perhaps a reduction in carbon in the castings corresponding to half of this as a result, either much less steel need be added to the borings for briquetting, or if the full amount is added, a much stronger metal is obtained. A founder can, therefore, not only utilize any steel scrap he may produce efficiently, but actually order or make his briquettes with just the proportion of this scrap he wants in them.

In the case of all steel briquettes, it may be said that for air or open-hearth furnace work, these excel the regular heavy steel scrap in point of working. Not only do they melt faster, thereby shortening the heat considerably, but from the uniform size and shape, they pile nicely in the furnace, allowing a better circulation of the gases to melt them, than can ever be obtained by irregular and large scrap pieces.

The briquetting of brass, bronze, aluminum, white metal, and other metals has not been touched upon, but it may be said that with these, the melting losses are the same as the solid metal when melted, for in the case of all the softer metals and alloys, they are pressed together so closely that they are, for all practical purposes, sound pieces of metal. The finer the scrap, the better the briquette; and hence a magnificent field has been opened for the economical recovery of the expensive metals in the foundry.

The near future will see a rapid development of the art in this country, and it is expected that other metallurgical reactions, such as de-sulphurization of iron, recarburizing metals, and other desirable processes will be presented to the metal industry through the agency of this new briquetting process under enormous pressures and proper time conditions.

ON THE MICROSCOPIC STRUCTURE OF IRON AND STEEL.

BY WILLIAM CAMPBELL, PH.D., SC.D. NEW YORK CITY.

It is comparatively easy to discuss the structure of iron and steel in a course of several lectures, but to do the same in thirty minutes is a most difficult task.

There are two courses open: First to give a popular exhibition of some typical lantern slides—and this has been the method most often adopted. Secondly, it can be assumed that one's audience has given some thought to the structure of the materials with which they work and therefore know something about the subject. This is the course I propose to follow, and I shall try to present a rational way of considering the problem.

OUTLINE OF THE PAPER. Introduction:

Methods of Research:
- (a) Microscopic, for Structure.
- (b) Pyrometric, for changes in heating or in cooling.

Results Obtained:
- (c) Examples of Type Structures. Cast Iron, Steel.
- (d) Examples of a Heat Treatment.
- (e) Examples of Faulty Material.

INTRODUCTION.

By many people metallography is thought to be a comparatively recent development of petrography, but this is not so. Henry Clifton Sorby, of Sheffield, was the first to make rock sections and to examine them by transmitted light under the microscope. Wishing to study the structure of meteorites, he very naturally started with the investigation of various kinds of iron and steel, in 1863. Work on such material being impossible by transmitted light, he was obliged to devise other means, which consisted of examining highly polished surfaces by the aid of

reflected light. Thus metallography is but a few years younger than petrography.

Its development, however, has been by no means so rapid. Dr. Sorby's first two papers, "On the Microscopical Photographs of Various Kinds of Iron and Steel" [1] and "On the Microscopical Structure of Meteorites and Meteoric Iron," [2] apparently attracted no attention; in fact, it was some twenty years later, on the publication of his two papers, "On the Application of very High Powers to the Study of Microscopical Structure of Steel" [3] and "On the Microscopical Structure of Steel," [4] that the great possibilities of the use of the microscope in metallurgy began to be realized.

On the continent, Martens had taken up the work, and in 1878 published a paper[5] on the microscopical examination of iron, which was followed after five years by one from Dolliak.[6] On this side of the water Hill,[7] Bayles [8] and Lynwood Garrison [9] made contributions to the science. In 1885 Osmond and Werth's paper, "Structure Cellulaire de l'Acier Fondu," [10] appeared, whilst in the same year Wedding published his paper on "The Properties of Malleable Iron Deduced from its Microscopic Structure," [11] From this time on, metallography has grown rapidly, and is now a recognized method of research; for by its aid we are able to unravel those problems of constitution and structure which can not be solved by chemical means alone.

The following publications may be specially noted for metallography:

The Journal of the Iron and Steel Institute.
The Revue de Metallurgie (Paris).
Metallurgie (Aachen).

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[1] British Association Report, 1864, 2, p. 189.
[2] Proc. Royal Society, XXIII, p. 333.
[3] *Jour. Iron and Steel Inst.*, 1886, I, 140.
[4] *Jour. Iron and Steel Inst.*, 1887, I, 255.
[5] *Zeit. des Ver. Deutscher Ing.*, XXI, 11, 205, 401. See also his papers Stahl und Eisen, II, 423 (1882), and Verhandl. des Ver. zur Beförderung des Gewerbfleisses, 1882, 233.
[6] Mitt. über Gegenstônde des Artillerie und Geniewesens, 1883, 9, 467.
[7] *Iron Age*, XXX, 15, p. 1 (1882); XXXI, I, p. 1 (1883).
[8] Trans. A. I. M. E. XI, 261 (1883).
[9] Trans. A. I. M. E. XIV, 64 (1885).
[10] *Comptes Rendus*, Vol. C, p. 450.
[11] *Jour. Iron and Steel Inst.*, 1885, I, 187.

International Journal of Metallography (Berlin).
The Journal of the Institute of Metals.

A great deal of pyrometric work has also been published in:
Zeitschrift fur anorganische Chemie.
Zeitschrift fur physikalische Chemie.

As a book of reference "Metallography," by C. H. Desch, is to be strongly recommended.

MICROSCOPE AND ACCESSORIES.

Any good type of microscope, with a fair working distance between the objective and the stage, can be used. A revolving stage is an advantage. As transmitted light cannot be used, the illumination must come from above by means of reflectors. When working with a one-inch objective the Sorby-Beck reflector is used, and with it we can obtain both vertical and oblique illumination. With higher powers than the one-inch, the Beck illuminator or the Nachet or Zeiss prism can be used, and are placed between the objective and the nosepiece.

The principle of the Beck illuminator and the prism is the same. The beam of light enters at the opening in the side of the tube, is deflected at 90° through the objective on to the object, thus illuminating it.

The Beck illuminator consists of a tube, which is screwed between the nose of the microscope and the objective, and is shown in place in Fig. 1. Within the tube is a thin glass plate, which can be adjusted at 45° with the axis by means of the milled head. This glass plate acts as the reflector and turns the beam of light from the horizontal through 90° into the tube of the microscope and so onto the specimen.

Fig. 2 shows the Zeiss prism, which acts in the same way. The beam of light enters through the hole in the side of the reflector and strikes the prism p: is reflected at 90° through the objective onto the specimen and illuminates it. Fig. 2a shows a top view of the same, with the milled head K which adjusts the prism. Given a microscope, all that is needed for metallographic examination is one of the above reflectors.

Three types of microscopes are made specially for metallographic work. They are (1) the Vertical stand, such as the

Sauveur, Leitz, etc. (2) Horizontal stand, such as the Martens' Stand of Zeiss. (3) The Le Chatelier type, such as the Le Chatelier of Pellin, the "micrometallograph" of Leitz, the Sauveur metalloscope, etc.

The main advantage of the vertical microscope lies in the fact that the stage can be raised and lowered by rack and pinion motion. When once the adjustment of the illuminating apparatus (lamps, condensers, etc.) has been made and the beam of light is centered on the aperture of the vertical illuminator, the position of the microscope tube is not altered, for all adjustments for focusing, etc., are made by the motion of the stage, and fine adjustment.

The Sauveur type of microscope is shown in Fig. 1, and has the Beck illuminator attached. On the stage is Sauveur's magnetic specimen holder, which insures the specimen being always level.

The *Martens' Stand,* manufactured by Zeiss, is made to work in the horizontal position, Fig. 3. Although the tube is provided with a coarse adjustment by rack and pinion T′, this is only used for transmitted light or for adjusting the tube to the illumination. Focusing is performed as in the Sauveur type by a rack and pinion movement T″ of the stage, to which is attached a fine adjustment M, which is actuated by the joint Tr and rod St, when focusing with the camera attached. Oblique illumination is obtained by the mirror Sp.

The *Le Chatelier Microscope* consists of a horizontal eyepiece tube fitted to a firm tripod support, in the body of which are fixed prisms so that the objective points upward. The specimen rests on a stage with its face downward toward the objective. Thus we require no mounting, and the specimen can be of any shape or size within limits.

After using the Le Chatelier microscope for some time the need of certain changes was felt, such as a heavier stage which could be moved by the usual rack and pinion, a simple method of changing the objective without moving the specimen from the stage, an eyepiece tube which could be moved to suit different heights and so forth. On inquiry of the firm of E. Leitz it was found that they had under way such a microscope following certain lines suggested by Dr. W. Guertler, and that the above changes would be embodied if found practical.

The most important feature of such a microscope is the system of illumination, which has been perfected [12] so that it is now adjustable. The compactness of the equipment can be seen in Fig. 4. The stand *S* consists of an upright which carries the microscope tube and the illuminating apparatus. The stage *T* may be raised or lowered by the rack and pinion and the fine adjustment *M*. The camera is attached by firm uprights to the frame B_1 which is fixed in position on the base of the microscope and lamp, B_2, by the wing-screw *r*. When using the camera, adjustment of lamp and stage is made by F_1 and F_2. The source of light is a 4-ampere 90° arc attached to column S_1 and can be raised or lowered by means of the rack and pinion. It requires a small external resistance.

When not using the camera the eyepiece *O* comes into play for it is fitted to a sliding tube at the end of which is a prism to deflect the image at 90° along this eyepiece tube. In Fig. 5 the objective *O* is seen screwed into the slide R_1 permitting of easy removal. By means of the head *R* and handle *n* the illuminating prisms can be adjusted and the beam of light varied by moving the lens attached to the milled head *S*. The end of the illuminating tube *B* is fitted with clips *h* to hold color screens. The beam of light can be widened and cut down by the iris diaphragm *I*, behind which is a shutter.

The working of the optical system is shown in Fig. 6. *B* represents the arc, *J* the iris diaphragm. The lens L^1 within the tube can be adjusted (by moving *s* in Fig. 5) so that an image of the iris is formed at *E* midway above the upper face of the prism *P* which by means of *R* (Fig. 5) may be moved backwards or forwards along the line *AB* and also tilted in the vertical plane. The rays of light pass through the objective *O* and illuminate the surface of the specimen *M* which lies face downwards on the stage. From the specimen part of the rays are reflected through the objective *O* onto the prism P^1 and thence to the eyepiece to form the image. This second prism is also capable of adjustment in the vertical plane parallel to the axis of the microscope, by moving the handle *n* (Fig. 5). Thus, by

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[12] Dr. W. V. Ignatowsky, "Illuminating System for Metallographic Microscope," *Zeits. f. wiss. Mikroskopie*, XXV, No. 4, 1909.

adjusting the lens L^1 and the two prisms P and P^1 we are able to eliminate stray and reflected light which causes the blurred pictures and images in ordinary microscopes using reflected light.

For low magnifications another method of illumination is used, similar to that advocated so long ago by Stead, and this is seen in Fig. 4. A thin glass plate or mica is fixed above the low-power objective at n and the arc light raised until the light passing through the lens L strikes the glass plate n and is deflected onto the surface of the specimen and illuminates it.

In Figs. 4 and 5 the Guertler Mechanical stage[13] is shown, which has a compound cross motion given by the two milled heads, T_1 and which may be read by two vernier scales to 0.1 mm. By means of a couple of sliding arms any given spot on the specimen surface can be readily found. The whole is attached to the regular stage T by the clamp p (Fig. 5), or can be made a part of the stage itself.

For ordinary work, however, the stage alone is used. When soft material is examined the brass stage-rings on which the specimen rests may be replaced by others of glass, as with the latter there is less tendency towards scratches caused by grit when the specimen is moved.

Thus this new microscope, called the micro-metallograph, has an adjustable system of illumination; a heavy stage-frame which can be fitted with a mechanical stage; a draw plate for changing the objective without moving the specimen from the stage; an adjustable eyepiece tube; and in addition is very compact and strong, whilst the arc lamp is part of the stand and requires but a small sized resistance. Compared with the older types of microscope and the larger arc-light illumination, this instrument has much to recommend it.

The Sauveur Metalloscope is shown in Fig. 7. As in the Le Chatelier and Leitz machines the objective points upwards and the necessity of mounting the specimen is done away with. The working of optical parts is made quite clear by Figs. 8 and 9 and need no further explanation.

Illumination.—For low powers a Welsbach burner is all

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[13] W. Guertler, "Ein Neues Metallmikroskop," *Metallurgie*, 1909, VI, 651.

that is required, with a bull's-eye condenser to focus the light. An oil or acetylene lamp can be used if necessary. For high powers, especially in photography, an arc lamp is best, because the time of exposure is greatly shortened. The ordinary arc requires a system of condensing lenses and cooling cells. A small arc, such as shown in Fig. 4, can be used without any cells and is very convenient and compact.

Photography.—The ordinary methods are used. The microscope takes the place of the camera lens and focusing is done by means of the rack and pinion motion of the microscope itself.

The camera can be used either in the vertical or horizontal position, depending on the type of microscope used.

It is necessary to get a sharp focus, not on the ground glass, but on a plane glass spot, by means of a magnifying glass. Also with magnifications over 100 diameters it is necessary to use a color screen and orthochromatic plates.

Preparation of Specimens.

Ordinary material can be cut with a hacksaw to convenient size and smoothed off on a file by fixing the file in a vise, and rubbing the specimen on it. Brittle and hard material such as white cast iron may be ground down on an emery-wheel.

To polish, the specimen is rubbed on the following grades of emery paper:

1. Rough. Commercial paper .....No. 0
2. Smooth. Commercial paper ....No. 00
3. French paper, Hubert make ....No. 0
4. French paper, Hubert make ....No. 00
5. French paper, Hubert make ....No. 000

The specimen is first rubbed on the rough paper till all the scratches from the file or emery wheel have gone. Then the specimen is dusted and wiped free from grit and is rubbed on the smoother paper, the new scratches being at 90° to those of the last paper, and so on through the series. All scratches from the previous board must be taken out before passing to the next.

The final polish is given on a bread-cloth block well moistened with rouge-water, this last stage taking from 3 to 6 minutes, according to the nature of the specimen. When finished, wash well under the tap, dry with alcohol immediately (or the

specimen will rust), and mop with a soft rag. Do not rub the specimen in any way.

Where a number of specimens are to be prepared at once it is a great saving of time to have the polishing papers and rouge cloth set on revolving discs, motor-driven, several forms of which are on the market.

The specimen as polished is now examined under the microscope using a magnification of 50 diameters; then under a higher power of say 250 diameters.

Any colored constituents are noted, such as slag in wrought iron, manganese sulphide and silicate in steel, graphite in cast iron, temper carbon (graphite) in malleable cast iron. Oxide, sulphide, etc., in copper and so forth.

Then develop the structure further by means of etching.

Wrought Iron.—Etch with picric acid (5 per cent. in alcohol) like steel. Examine for pearlite, then develop the grain size of the ferrite by dipping part of the specimen in 10 per cent. HNO_3 for 10 to 20 seconds, wash well and dry in the alcohol. The slag areas are deeply attacked and the grain and orientation of the ferrite shown up. Prolonged etching with picric acid gives better results but is slower.

Steel.—Etch with 5 per cent. picric acid in alcohol—cover specimen and rock it back and forth until the solutions become very dark. Wash, dry with alcohol. Pearlite is attacked and turns brown to blue-black. Ferrite and cementite are not attacked. In the neighborhood of 0.8 per cent. carbon it is quite difficult to distinguish between ferrite and cementite. They may be easily distinguished by boiling in a solution of picrate of soda, 2 parts picric acid to 98 parts of a solution containing 25 per cent. caustic soda, which turns Fe_3C black, but leaves ferrite bright.

Note the relative amounts of ferrite and pearlite or cementite and pearlite and calculate the approximate amount of carbon present assuming pearlite contains 0.8 per cent. carbon, for low carbon material, 0.7 per cent. for medium carbon and 0.6 per cent. for rail steel, etc.

Hardened Steel.—Use picric acid. Then etch with 4 per cent. nitric in amyl alcohol or 2 per cent. in water, and rub off the stain on chamois skin pad.

Cast Iron.—Etch with 5 per cent. picric acid as above. The shape of the graphite, the amount of pearlite, ferrite or cementite are important.

Copper Alloys.—Those rich in copper etch with HNO_3, 50 per cent. in water, ammonium persulphate in water gives good results.

Bearing Metal and White Metals in General.—Use 10 per cent. HNO_3, in water, wash well and dry with alcohol as above. Don't over-etch or the specimen will have to be repolished. Alloys with *zinc* base are etched with 2 per cent. nitric acid in alcohol.

NOTES.—*Wrought Iron.*—Note the amount and shape of the patches of slag, whether the metal looks strong or weak therefrom. After etching note size of grain. Any pearlite present will appear black. Is its presence due to carbonization in a charcoal finery hearth or has the material been made from scrap steel instead of "muck bar" from puddled iron? If the material has been in service, note any indications of strain as revealed by slip lines, etc.

Steel.—The size of grain is important and depends mostly on the amount of reduction during mechanical treatment or the annealing temperature in cast metal.

The amount of carbon is indicated by the amount of pearlite present. The presence of manganese sulphide and silicate is important; any segregation to be noted. Overheating is shown by the extremely coarse grain and feathery ferrite. Burning is shown by the presence of oxide between the grains.

In high-carbon steel the grain ought to be small. Segregation of cementite into globules shows overheating, whilst extreme overheating causes the cementite to break down into graphite and ferrite.

THE THERMAL DIAGRAM.

This is commonly called the freezing point curve. It is more than this. It shows the relation of the various constituents with variation in composition and temperature.

Thus, in Fig. 10, temperature is represented in the vertical and percentage composition in the horizontal. Omitting the dotted lines the curve A D L shows the beginning of freezing,

the curve A E D F is the end of freezing or, in heating, the beginning of melting. Hence below this curve the alloys are solid. The alloy D T is that with the lowest freezing point, and therefore the "eutectic" by definition. It consists of a mechanical mixture of the two constituents, in this case, iron with 2 per cent. of carbon in solid solution (called austenite) and carbide of iron (6.6 per cent. C or cementite). On freezing alloys from 0 to 2 per cent. carbon consist of austenite and are steels, alloys with over 2 per cent. of carbon are cast irons and consist of crystals of austenite set in the eutectic or groundmass (DT) if less than 4.2 per cent. carbon, or of crystals of cementite set in the eutectics if more than 4.2 per cent. carbon.

The diagram also shows us the changes which take place in the solid austenite. At 1,125° C. the austenite holds a trace over 2 per cent. carbon in solution. As the temperature falls the amount of carbon in solution falls also and cementite separates out of the austenite as shown by the curve E S, which is the solubility curve of carbon (cementite) in iron (gamma modification). Furthermore, the curve G O S shows the separation of ferrite from the solid solution austenite (G O gives beta ferrite, O S gives alpha variety, which is the only one magnetic).

Now, at 700° C. the line P S K shows a sudden transformation whereby the austenite (0.9 per cent. C or S) splits up into a mechanical matrix of ferrite and cementite, which is called pearlite. The change in the *solid state* is similar to that from the liquid to the solid at 1,125° C. or E D F, and is called the "eutectoid" change.

In short we have the following areas shown on the diagram:

(1)	Above	A D L	All liquid.
(2)	In	A D E	Austenite crystals + liquid.
(3)	In	L D F	Cementite crystals + liquid.
(4)	In	A E S O G	Austenite.
(5)	In	G O S P	Ferrite + Austenite.
(6)	In	E S R′	Cementite + Austenite.
(7)	In	E D T′ R′	Austenite + Eutectic.
(8)	In	D F K T′	Cementite + Eutectic.
(9)	In	P S Q	Ferrite + Pearlite.
(10)	In	Q S K	Cementite + Pearlite.

This latter area, however, can be again divided up according to the age of the cementite.

(11) In	T T′ K	Crystals of Cementite + Eutectic Cementite + secondary Cementite (E S) + Pearlite.
(12) In	R′ T′ T R	Eutectic Cementite + secondary Cementite + Pearlite.
(13) In	S R′ R Q	Secondary Cementite + Pearlite.

The development of the iron-carbon diagram has been gradual and we are not yet agreed as to its correctness on all points.

The main points in its history are:

Osmond distinguished three forms of pure iron—alpha and beta and gamma—whose transformation points are 760° and 900° C., or A_2 and A_3, and the last two are non-magnetic. The solubility of carbon in gamma iron reaches a maximum of about 2 per cent., while in ferrite (alpha iron) it is nil.

To Roberts-Austen [14] we owe the first temperature-composition curve for the series, which consisted of the lines shown in Fig. 10, namely, A B C: a B f: G O S: M O: P S K and S E in part. In his lectures he taught that the alloys of iron and carbon consisted of two constituents in freezing, namely, graphite and a solid containing up to 2 per cent. of carbon in solution. That at a lower temperature this solid containing carbon in solution rearranged itself into two constituents, ferrite or pure iron and cementite or iron carbide, just as the series ice-salt changes from the liquid to the solid state on fall of temperature. Similar curves were obtained by Osmond and by Le Chatelier independently.

In 1899 Sir William Roberts-Austen included an equilibrium diagram in the Fifth Report of the Alloys Research Committee of the Institution of Mechanical Engineers. (London.)

The curve for the iron-carbon series was corrected and brought up to date. The point A (Fig. 10) was placed just below 1,600° C., a at 1.2 per cent. carbon and 1,120°, B at 4.3 per cent.

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[14] Fourth Report to Alloys Research Committee, Pl. ii, 1897. Institution of Mechanical Engineers, London.

carbon, G at 890°, M at 770°, S at 690° between 0.8 and 0.9 per cent. carbon. The point E at 1.8 per cent. carbon and 1,000° C. formed the summit for the curve denoting the separation of cementite which fell with increase in total carbon, till at about 4.25 per cent. carbon it met the line S K at T' and ended. Above 4.25 per cent. carbon ferrite separated. The two lines denoting the separation of cementite and ferrite above 2 per cent. carbon were hypothetical and were soon eliminated from the diagram. Just below the line a B f a parallel line was drawn at about 1,060° C. on the suggestion of H. Le Chatelier, to denote the possible solidification of cementite eutectic in white iron.

Starting with Roberts-Austen's data, Rooseboom for physical-chemical reasons added to the curve so that certain principles of solution were brought out thereby. His modification consisted essentially of adding the lines A a, and joining the point a by a line to the summit of the curve denoting the separation of cementite at about 1,000° C. and 1.8 per cent. carbon. A horizontal line was drawn from this point denoting a change at a constant temperature 1,000° C. The beginning of freezing is represented by A B C the "liquidus," while A a B f the "solidus" denotes the end of freezing and below these limits the alloys are solid. When a liquid alloy cooled down to the temperature A B dendrites separated out and contained a maximum of 2 per cent. carbon in solid solution. [This solid solution has been called "Mixed Crystals," martensite, gamma iron and is now known as austenite.] In alloys containing more than 2 per cent. carbon a groundmass, the martensite-graphite eutectic, makes its appearance and its evolution of heat on freezing is denoted by the horizontal line a B f. The branch B C denotes the separation of free graphite. Thus we find that from 0 to 2 per cent. carbon, the alloys solidify as mixed crystals (solid solutions); from 2 to 4.3 per cent. or a to B, the alloys solidify as dendrites of the solid solution (2 per cent. carbon) set in an increasing groundmass or eutectic of graphite and the solid solution; while above B or 4.3 per cent. carbon we have free graphite and the eutectic. Beneath the line a B f (at 1,130° C.), therefore, we are dealing with a solid conglomerate of two phases, graphite and martensite (with 2 per cent. of carbon in solution). The amount of carbon in the solid solution falls with the tempera-

ture and we have a further separation of graphite till at about 1,000° C. we have only 1.8 per cent. c in solution. This separation was denoted by a line from a (2 per cent. c) to summit of the cementite line S E of Roberts-Austen (1.8 per cent. c and 1,000° C.). This means that in the normal state of equilibrium we have an abrupt transformation, thus:

Martensite (1.8 per cent. c) + graphite = cementite (Fe_3C). The temperature 1,000° is therefore a transition point, in other words, at this temperature only can we have three phases in equilibrium, therefore in all alloys the transformation of martensite and graphite into cementite must occur at this temperature, which was denoted by the horizontal line. As the temperature falls below 1,000° C. the solubility of carbon in the solid solution martensite falls along the curve E S. This continues until we reach the line P S K at 690° when the residual martensite, with 0.85 per cent. carbon in solution changes over into a conglomerate of ferrite and cementite, which we call pearlite. The formation of this eutectöid pearlite causes recalescence. To sum up, according to the work of Rooseboom, in slowly cooled iron or steel in equilibrium we should only find ferrite and cementite.

The publication of Rooseboom's application of the phase-rule to the iron-carbon series [15] raised quite a storm of criticism, mostly practice versus theory. It was argued that in most cast irons we find ferrite, cementite and graphite, that the data on which the work was founded were wrong; that the phase-rule was not applicable outside strictly chemical lines and so forth. In the first place, most cast irons are not pure alloys of carbon and iron. In the second, they are very seldom in equilibrium. The reaction between martensite (austenite) and graphite to form cementite would naturally be extremely slow and hence in ordinarily cooled cast iron we should expect to find graphite by lag. It was pointed out that the reverse, cementite changing to graphite and martensite (austenite), occurred quite readily in the manufacture of malleable castings. On the other hand, rapid cooling tends to produce much cementite, while slow cooling yields much graphite.

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[15] *Jour. Iron and Steel Inst.* 1900, II, p. 311.

In regard to the accuracy of the data, Carpenter and Keeling [16] ran a series of cooling curves for 38 alloys of carbon and iron as pure as possible and their results confirm the accuracy of Rooseboom's diagram, allowing for the differences in their determinations. For example, their freezing point for pure iron begins at 1,505° C. For the eutectic alloy with 4.3 per cent. carbon at 1,139° C.

The line a B f rises slightly from about 1,110° C. at 2 per cent. carbon to 1,122° C. at 2.25 per cent. carbon, to 1,139° C. at 2.75 per cent. carbon. The line P S K rises slightly also from about 690° C. with 0.12 per cent. carbon to 700° C. with 0.9 per cent. carbon, to about 710° C. Hence we may judge that the *data* were accurate.

While Rooseboom's interpretation might readily be accepted for gray cast irons, when we consider the structure of white cast irons (shown in Figs. 13 and 14), we see that the groundmass is a eutectic consisting of primary cementite and the solid solution martensite (austenite, which afterwards transformed into pearlite). Were graphite a primary product and cementite a secondary one, slow cooling ought to promote the occurrence of the latter, rapid cooling yielding the former. It is a well-known fact that slow cooling promotes the formation of graphite and rapid cooling or chilling gives us cementite. In short, very slow cooling produces a eutectic of austenite and graphite, rapid cooling a eutectic of austenite and cementite. The presence of silicon usually emphasizes this effect.

The explanation that the cause of the difference between white and gray iron is silicon, does not always hold good. Carpenter and Keeling's alloys show with about 0.16 per cent. Si, up to 3.0 per cent. carbon, it was all combined, but an alloy with 0.06 per cent. Si yielded 2.14 per cent. graphite out of 3.87 per cent. total carbon. In Wust's work[17] up to about 3 per cent. carbon there was only a little graphite, while one alloy with 0.009 per cent. Si gave 2.33 per cent. graphite with 3.76 per cent. total carbon, and another with 0.11 per cent. Si gave 3.31 per cent. graphite out of a total carbon of 4.82 per cent. In

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[16] National Physical Laboratory. Collected researches, I, pp. 277–244.
[17] *Metallurgie*, II, 1.

these exceptional cases silicon can hardly be the main cause of the graphite.

When we take a piece of high-carbon tool steel ($C = 1.5 - 2$ per cent.), or of blister steel and heat it up to the burning point, the temperature of the line a A, Fig. 10, several globules of liquid very rich in carbon are squeezed out at the surface. On quenching this material a section shows it to be composed of austenite grains, between which occur films and patches of white cast iron, the cementite-austenite eutectic. If the material be cooled in the air instead of quenching the same structure is met with, excepting that the austenite changes over in the solid to cementite and pearlite—S E and S K (Fig. 10).

On the other hand, some pure electrolytic iron was melted in a graphite crucible (Acheson) and cooled slowly in the furnace. It consists of plates of graphite, grains of pearlite, with coarse patches of cementite. Total carbon about 4 per cent. Thus the time element plays a most important part in determining whether the carbon will be free or combined.

We have found many cases in which there has been a change from combined carbon to graphite during the original cooling. The cast iron shows two independent structures: (1) grains of normal gray cast iron, consisting of graphite flakes set in pearlite; (2) an irregular network of gray cast iron of much finer texture, small graphite flakes and globules set in a blurred groundmass of ferrite and pearlite. This network most probably is due to a transformation from white cast iron, the whole iron ($1 + 2$) being originally mottled.

In some cases we have seen small castings (1 inch thick), which have a gray shell and a white core produced from the original cooling, a reversal of what we usually find. The only reason seems to be that the outside was originally white and in cooling changed over into gray.

Stansfield, in a paper on the Present Position of the Solution Theory of Carburized Iron [18], comes to the conclusion that graphite does not combine with iron on slow cooling to 1,050° C., and that the 2 per cent. of carbon which the iron at first holds in solid solution is rejected as graphite and not as cemen-

[18] *Jour. Iron and Steel Inst.*, 1900, II, 317.

tite, if the metal is cooled sufficiently slowly. Instead of the line from a denoting the further separation of graphite and cutting the cementite line S E, a line a n is drawn to the left of and parallel to E S, so as to cut G O S. This new line denotes the solubility of graphite in austenite, which is therefore much less than that of cementite in austenite. That graphite is not formed in steel, he concludes, is due partly to the absence of nuclei of graphite on which further deposits might take place, partly to the length of time required for the separation of graphite, and partly to the mechanical pressure which must oppose the formation of bulky graphite in steel. The phase-rule demands that in equilibrium there be but two constituents present. Graphite being the more stable, these two constituents must be ferrite and graphite.

From the evidence we have on hand it seems to make the subject clearer if we consider that we are dealing with two distinct and separate systems, following Benedick's [19].

1. *White Cast Iron. Metastable.* Alloys of *austenite* and *cementite.* Produced by rapid cooling (also absence of silicon, presence of manganese, etc.), and more liable to occur when iron is poor in carbon. The freezing curve is shown in Fig. 10 by the heavy lines A D L, A E D F. The temperature of the line E D F is about 1,125° C.

The line A D denotes the freezing of crystals or dendrites of austenite holding a maximum of 2 per cent. carbon in solid solution as cementite; the line D L denotes the freezing of crystals or plates of cementite, while the line E D F shows the solidification of the groundmass or eutectic of austenite and cementite. Thus up to 2 per cent. carbon the alloys form a series of solid solutions. Between E and D or from 2 to about 4.3 per cent. they consist of dendrites of austenite surrounded by an increasing matrix of austenite and cementite, the eutectic. Above D or 4.3 per cent. they consist of increasing amounts of cementite plates set in the same eutectic or groundmass. Fig. 13, magnified to 60, is a section of washed metal containing 3.75 per cent. carbon. Si = 0.03: P = 0.012: S = 0.020. It consists of a few dark etching grains of austenite set in a groundmass

[19] *Metallurgie*, 1908, Part II.

which is a mixture of dark etching austenite and bright cementite and is the eutectic. Fig. 14 shows a portion of the same under 260 diameters. The alloys occurring on the right of B are illustrated in Fig. 17, which is a section of spiegeleisen very slowly cooled, magnified 50. It consists of plates of cementite (here a carbide of iron and manganese) set in the eutectic of austenite and cementite.

II. *Gray Cast Iron. Stable.* Alloys of *austenite* and *graphite.* Produced by slow cooling (also by the presence of silicon, absence of manganese, etc.) and more liable to occur in irons very rich in carbon. The freezing curve is shown by the lines A B C, A a B f in Fig. 10.

The structure of an alloy between a and B is shown by Fig. 11 x 50 diameters, a piece of cast iron containing 2.9 per cent. C, 1.44 per cent. Si, 0.23 per cent. Mn, unetched. The dendrites of austenite are surrounded by a matrix or eutectic of austenite and graphite, which froze on reaching the temperature a B. Fig. 12 shows the eutectic of austenite and graphite, a piece of gray iron, corresponding to the point B.

Cast irons between white and gray (mottled) consist of grains of gray surrounded by a network of white, the gray apparently freezing a little ahead of the white.

Figs. 15 and 16 show the effect of chilling. Fig. 15 the outside of a small round cast in an iron mold consists of the austenite-cementite alloy, while Fig. 16 the interior shows grains of gray with a white network (as well as some dendrites of austenite).

Thus our two systems are composed of graphite-austenite or cementite-austenite on freezing.

The austenite, however, is not stable but changes over with fall of temperature. This it can do in two ways: (1) Separation of cementite; (2) Separation of graphite.

(1) With fall of temperature below E D F, say 1,125° C., the austenite becomes supersaturated with cementite, being no longer able to hold 2 per cent. of carbon in solution. The cementite therefore separates out along the line E S, which denotes the composition of the residual austenite grain with fall of temperature till at 700° C., or the temperature P S K, the residue contains 0.85 per cent. C, and splits up into a mix-

ture of ferrite and cementite or the eutectoid pearlite. Hence the final products will be cementite and pearlite, which are the constituents of Figs. 13 and 14, the pearlite appearing black, the cementite white. We have, therefore, three generations of cementite—(a) the constituent of the eutectic which solidified at 1,125° C., (b) the excess which separated on the line E S, (c) the constituent of the eutectoid pearlite, which separated out at the temperature S K, or during recalescence.

In gray cast iron the line A B denotes the beginning of the freezing of dendrites of austenite as before, the line B C the separation of flakes of graphite, while a B f shows the solidification of the groundmass, or eutectic of austenite and graphite at 1,135°. Thus we have replaced the cementite of our white irons by graphite. There is one other great difference. The austenite which separates out does not have a constant amount of carbon in solid solution In other words, the point a can vary from 2 to 0 per cent., carbon, depending largely on the Si and other impurities present. As the temperature falls the austenite (0-2 per cent. C) rearranges itself into ferrite and pearlite, cementite and pearlite or pearlite alone, according as the percentage of dissolved carbon was less than, greater than or equal to 0.85 per cent., following the curves G O S and S E.

(2) By long and suitable annealing, however, we can produce graphite and ferrite, the stable forms. Hence to complete the stable diagram the line a n is added to denote the separation of graphite out of the austenite. Now this leads to the startling assumption that all steel is metastable (Stansfield).

Goerens and Gutowsky [20] have shown that generally gray cast iron freezes as white and subsequently breaks down into gray; in other words, we first have the austenite-cementite system which just below the freezing point changes over into the austenite-graphite wholly or in part. On repeating some of their work this was found to be undoubtedly the case with pure iron-carbon alloys. Fig. 18 shows a piece of iron-carbon alloy, carbon 4 per cent., quenched just below solidification. The dark irregular bands have a core of graphite evidently growing out of the cementite-austenite eutectic. A piece

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[20] *Metallurgie*, V. 5, p. 45.

quenched at a slightly higher temperature was all cementite-austenite. Another quenched at just above 700° was all graphite-austenite.

Thus it would seem that we have not yet reached the solution of the constitution of cast irons. This is made apparent when we consider the latest diagram by Upton.[21]

This calls for the following changes:—

Graphite + Austenite = Fe_6C at 1095° C.

At 800° Fe_6C changes over into Fe_3C and austenite.

At 615° Fe_3C breaks up into Fe_2C and Alpha iron (ferrite).

However, at present the most satisfactory working diagram is the double one showing the two systems, stable and metastable.

Leaving the cast irons and taking up the iron-carbon series from 0 to 2 per cent. in the steel division, the diagram explains in a very satisfactory manner the changes which take place.

Starting with 0 per cent. C or wrought iron. Fig. 19 is a section of a piece of pipe skelp x 50 dias. and etched with 10 per cent. nitric acid. It consists of grains of pure iron or ferrite with more or less regular polygonal boundaries and some dark patches of slag. Compare this with Fig. 20. A piece of 0.1 per cent. C steel slowly cooled from 1,000° C. x 250 dias. As before we have the polygonal grains but in places are seen irregular dark etching patches. Under a high power these are seen to be composed of alternate laminae of ferrite and cementite, which we call pearlite. Now in cooling down from 1,000° this alloy with 0.1 per cent. C consisted of grains of austenite (with 0.1 per cent. carbon in solution) until at about 880° C. on reaching the line G O ferrite began to separate out and continued to do so until at 700° the line P S was reached. At this temperature the residues of the austenite grains consisted of about 0.9 per cent. C (were saturated) because the composition of the austenite follows the line G O S. Now below P S austenite is unstable so that here (700°) the residual austenite breaks up into a mechanical mixture of ferrite and cementite or pearlite. This is the lowest change and hence is called the eutectoid.

[21] *Jour. Physical Chemistry*, 12 (1908), 507.

As the carbon is increased in the steel the amount of pearlite increases and the temperature at which the ferrite falls out of solution in the austenite falls also, following the curve G O S.

Fig. 21 is a steel containing 0.5 per cent. C x 260. Now the pearlite has increased so that it is more than half the mass and the ferrite forms rough envelopes round the grains. At 0.9 per cent. C (0.6 per cent. C with 1 per cent. Mn and air cooling after rolling, etc.) the whole mass consists of pearlite. In other words, the austenite at 700° C. (point S) changes directly over into pearlite.

When the carbon is increased above 0.9 per cent. a new constituent appears as hard bright envelopes round the grains. This is cementite or iron carbide. Fig. 22 x 60 shows a piece of blister steel, 1.5 per cent. C., the white envelopes are cementite and the grains are pearlite. On account of the very slow cooling the lamination of the pearlite is evident at this low magnification.

Just as the ferrite separates out of steels with less than 0.9 (or S) per cent. C on reaching the line G O S, so cementite separates out of high carbon steels when they cool down to the line E S. The change of the residual austenite into pearlite occurs at 700° C. as before.

The microscope can be used in the determination of various materials as, for instance, in the case of wrought iron, charcoal hearth iron and piled scrap steel. Fig. 19 showed the genuine wrought iron. Fig. 23 shows some charcoal hearth skelp, longitudinal section x 50, etched with picric acid. The black masses are slag. The white is ferrite, but through the ferrite runs two bands containing pearlite, due to carburization in the hearth. Now with piled scrap there is not this perfect gradation between the iron and the steel. There are sharp boundaries. This is shown in Figs. 24 and 25 from a piece of wrought iron made from reheated scrap iron and steel.

Coming next to the question of HEAT TREATMENT as a rule a coarse structure means weakness. When a metal or alloy freezes we generally get the formation of dendrites or pine-tree crystals. Fig. 26 shows, natural size, the surface of a slab of antimony. Now steel crystallizes or freezes in just such pine-

tree crystals, and we have then to break them up either by mechanical means or by heat treatment.

In forging or rolling we break them up more or less so that the final product is of fine grain. With castings we "anneal" and thus produce a fine grain.

In the case of a steel casting, as the temperature reaches the curve A D the metal begins to freeze and is completely solid on reaching A E. The rate of passing through this freezing range determines the size of grain. When solid the casting consists of grains or dendrites of austenite, *i. e.*, all of the carbon is in solution. On further cooling no further change takes place until the line G O S is reached. Then ferrite begins to separate out around and in each grain until at 700° (P S) the residual austenite splits up into pearlite. Now to obtain a fine grain we reheat. Heating to temperatures below P S or 700° causes no change normally On passing this temperature the coarse pearlite changes over into fine grained austenite and is refined. To complete the refining, however, we must heat to above the line G O S to take the coarse ferrite all into solution. Thus the lower the carbon content, the higher the refining temperature.

In actual practice the changes on cooling take place at slightly lower temperatures than on heating due to lag, so that we have to heat to say 25° C. above the line G O S for complete refining.

Manganese, etc., make the lag more pronounced. To take an example. Fig. 27 shows a casting with 0.35 per cent. C, 0.66 per cent. Mn x 40 diameters. Only part of a grain is seen, the structure being so coarse. The ferrite shows up in characteristic rectilinear structure. Fig. 28 shows the smallest structure met within the section.

Fig. 29 shows the same steel heated to 805° C. for 15 minutes, and slowly cooled. The refining is not complete because the ferrite shows remains of the original structure. Fig. 30 heated to 830° C. for one hour shows complete refining with no trace of the original coarse ferrite, because the line G O S had been passed.

There are cases where such treatment fails to give complete refining. Fig. 31 x 40 shows a section of an ingot with 0.45

per cent. C, .78 per cent. Mn. The structure is so coarse that only part of three grains can be seen. Heating to above the line G O S failed to give complete refining as shown in Fig. 32, where we still see coarse patches of ferrite. This is due to the fact that the steel contains films of manganese sulphide and silicate which acted as nuclei on which the ferrite reprecipitated on cooling. This is even more marked in Fig. 33 with 0.5 per cent. C x 40, which had failed to refine commercially. Fig. 34 x 40 shows the same heated to 830° C. for one hour, well above G O S. As before the ferrite has reprecipitated on the network of manganese sulphide, etc., and the ductility has suffered.

In the heat treatment of high carbon steel we ought to heat above S E to take all of the cementite into solution for complete refining This, however, causes overheating and often breaks down the carbide with the production of graphite, on account of the fact that the envelopes of cementite tend to break down and form globules, heating to just above P S K generally refines the steel.

EXAMPLES OF FAULTY MATERIAL.

Of all the uses of metallography the determination of the cause of failure is the most valuable. In wrought iron the amount and relative size of the slag is determined with ease. In steel the size of grains, inclusions of manganese sulphide, silicate, blow holes, segregation, etc., can be seen. For hardened material the grain size indicates correct quenching temperature, but because tempering causes no change in the grain size but a change of the internal structure of the grain itself (austenite changing over into pearlite through a whole series of decomposition products called martensite, troostite, sorbite, etc.) the microscope is of comparatively little use.

In the case of cast iron, however, it would seem that we might apply this method of research profitably The structure of white cast iron has already been considered. In the case of gray, coarse graphite must mean weakness. The relative amounts of cementite, ferrite and pearlite in the matrix and their arrangement must determine the physical properties. The following illustrations will serve as types.

Fig. 35 x 50 shows the interior of a small gray casting unetched, whilst Fig. 37 shows the surface. The arrangement of the graphite is quite different. Figs. 36 and 38 show the interior and surface, respectively, after etching. The network of cementite is different and in Fig. 38 much of the graphite is surrounded by ferrite, indicating that this is the product of the decomposition of cementite.

Comparing Figs. 39 to 40 the differences in structure are very marked. Fig. 39 is a section of a faulty cast iron fly wheel, the cause of brittleness being the coarseness of the graphite plates. Fig. 40 shows some very strong gray iron the graphite being in much shorter flakes, the groundmass being mainly pearlite.

Fig. 41 is a piece of high silicon iron. The coarse graphite plates are surrounded by a thick envelope of ferrite. The combined carbon is low and the iron very soft. Compare this with a piece of soft iron for small castings. We see in Fig. 42 a network of cementite with grains of gray between. The graphite is so fine that it is lost in the etching of the pearlite. The resulting metal is strong.

With such variations in structure it would seem certain that a careful study of structure must lead to results of commercial importance and value.

Conclusion.—It may seem that the material here presented is too technical for the novice and too elementary for the metallographer. The aim has been to show *first* that the microscope is easily applied. *Second,* that the thermal diagram although not yet perfectly understood, has some value, especially in heat treatment. *Third,* that metallography is a very great aid in heat treatment, and *lastly,* that for the examination of faulty material and a comparison with good, it is unexcelled, because while an analysis will tell us what is present in our iron and steel, the microscope tells us how it occurs. And we all recognize the relation between structure and physical properties.

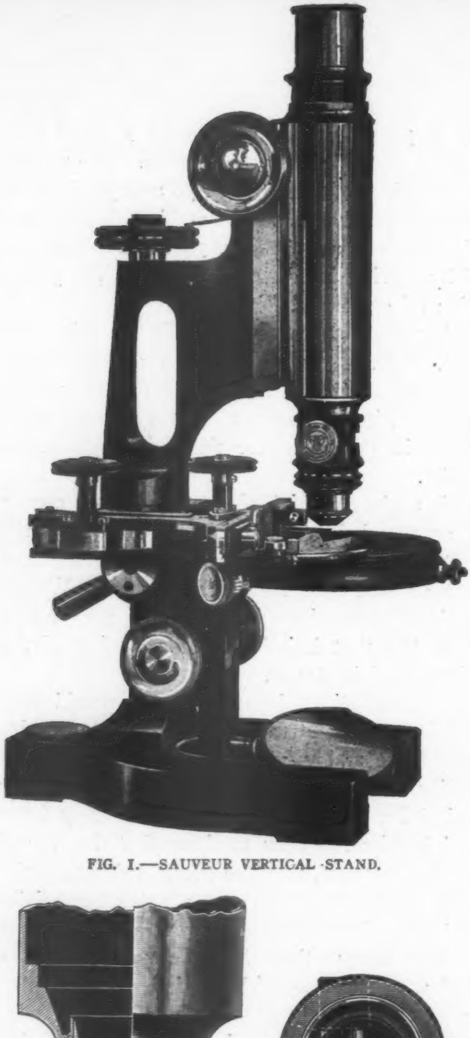
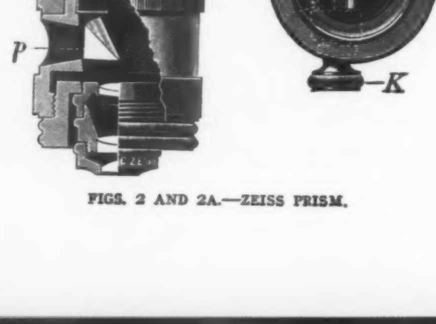


FIG. I.—SAUVEUR VERTICAL STAND.



FIGS. 2 AND 2A.—ZEISS PRISM.

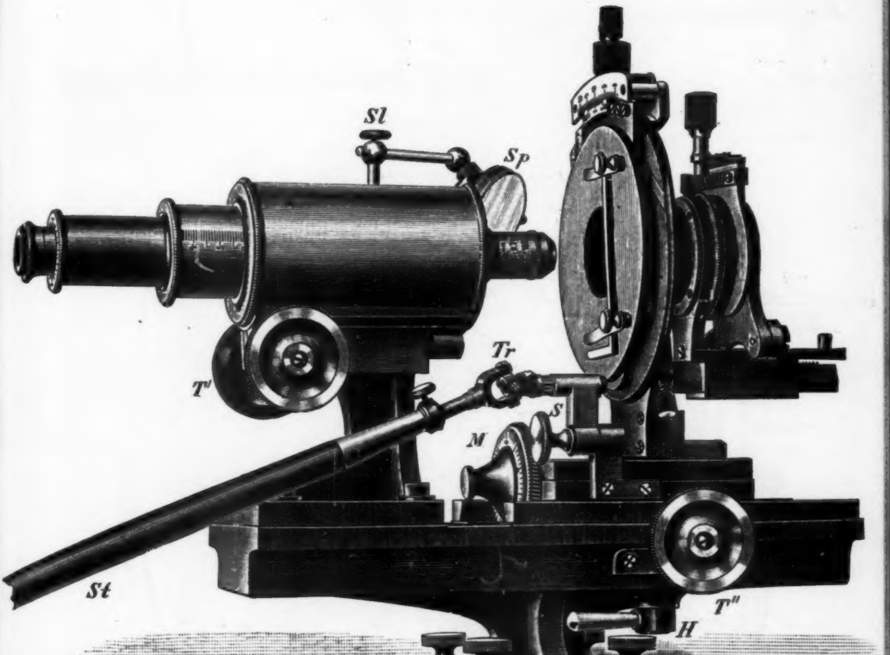


FIG. 3.—MARTENS STAND.

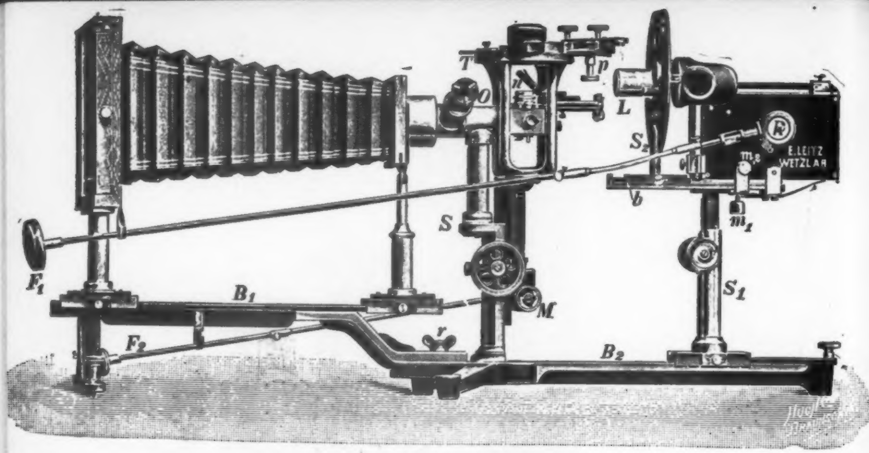


FIG. 4.—LEITZ MICROMETALLOGRAPH.

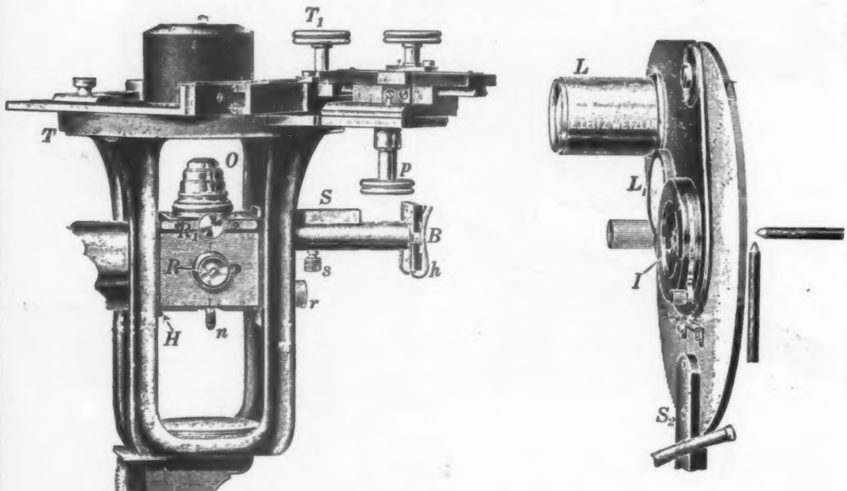


FIG. 5.

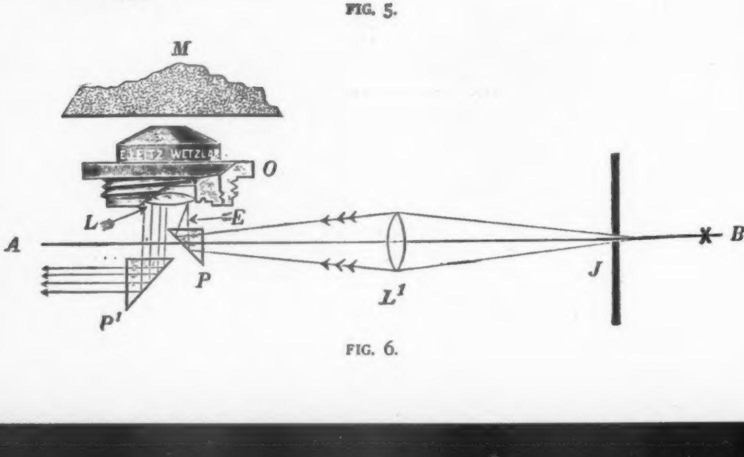


FIG. 6.

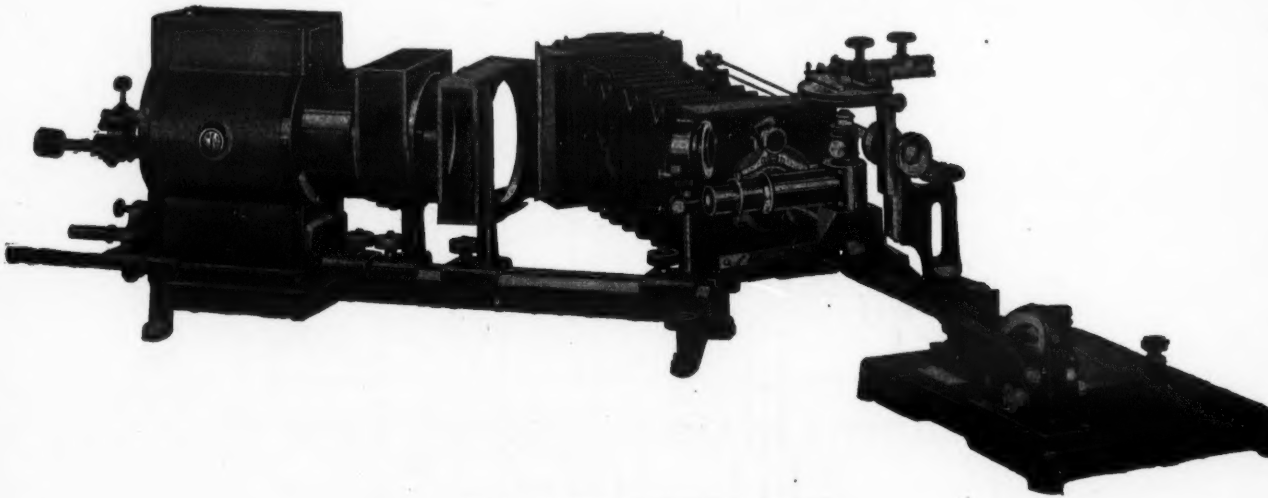


FIG. 7.—SAUVEUR INVERTED METALLOSCOPE.

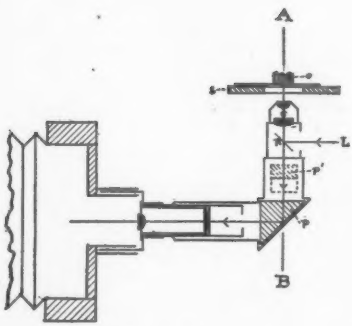


FIG. 8.

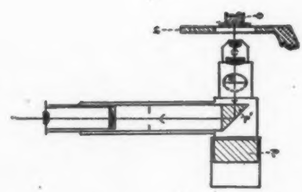


FIG. 9.

Fig. 8.—Sauveur Inverted Metalloscope. Vertical Section, Front View.

Fig. 9.—Sauveur Inverted Metalloscope. Vertical Section, End View, on A B (Fig. 8).

L = Source of Light.

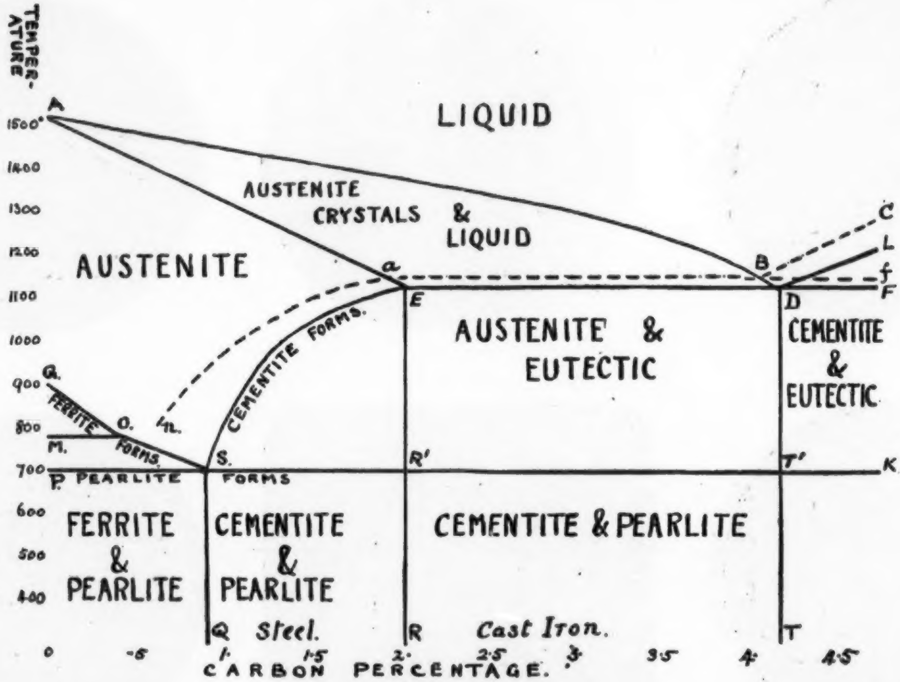
R = Vertical Illuminator Reflector.

P′ = Totally Reflecting Prism Which Reflects Image into the Eye-tube when Latter is pushed in.

P = Totally Reflecting Prism Which Reflects Image into Camera when Eye-tube is pulled out.

S = Metalloscope Stage.

O = Specimen.


TEMPER-ATURE
1500°
1400
1300
1200
1100
1000
900
800
700
600
500
400
A
LIQUID
AUSTENITE CRYSTALS & LIQUID
AUSTENITE
a
B
C
L
f
F
E
D
AUSTENITE & EUTECTIC
CEMENTITE & EUTECTIC
CEMENTITE FORMS.
Q.
FERRITE
O.
n.
M.
FORMS.
S.
R'
T'
K
P. PEARLITE
FORMS
FERRITE & PEARLITE
CEMENTITE & PEARLITE
CEMENTITE & PEARLITE
Q
Steel.
R
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T
0
·5
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CARBON PERCENTAGE.

FIG. 10

FIG. 11

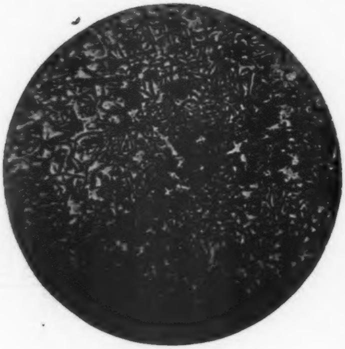

FIG. 12

FIG. 13

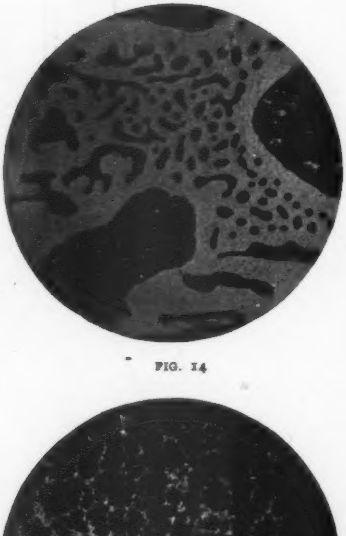

FIG. 14

FIG. 15

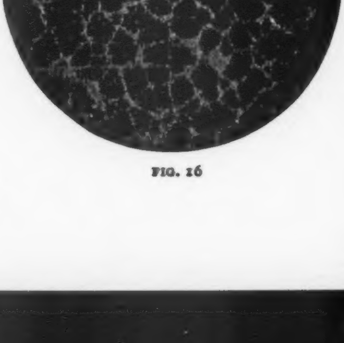

FIG. 16

FIG. 17

FIG. 18

FIG. 19

FIG. 20

FIG. 21

FIG. 22

FIG. 23

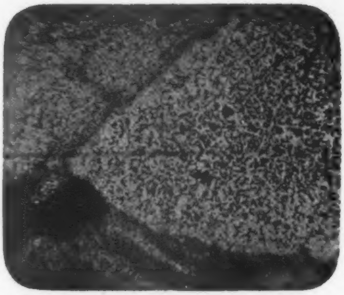

FIG. 24

FIG. 25

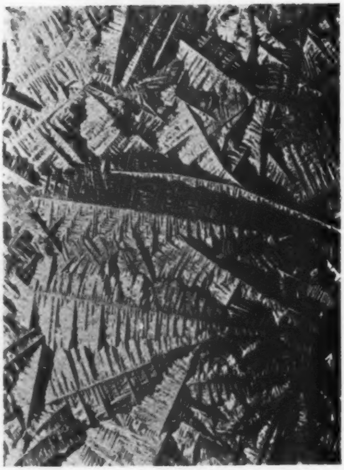

FIG. 26

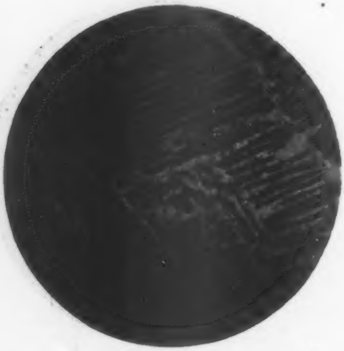

FIG. 27

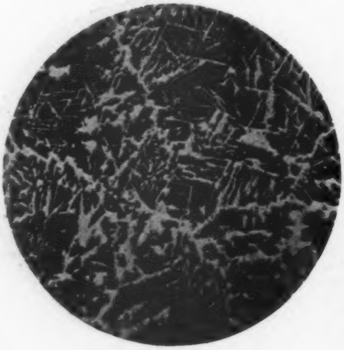

FIG. 28

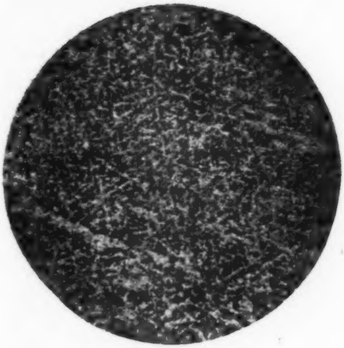

FIG. 29

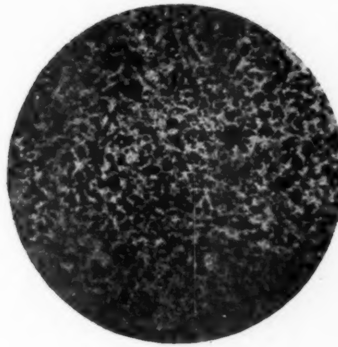

FIG. 30

FIG. 31

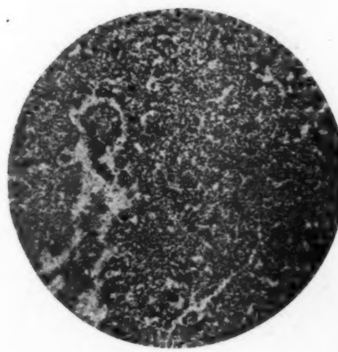

FIG. 32

FIG. 33

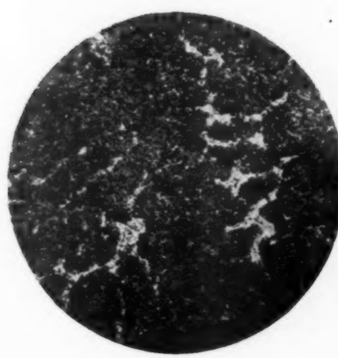

FIG. 34

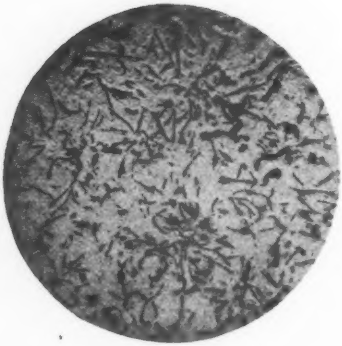

FIG. 35

FIG. 36

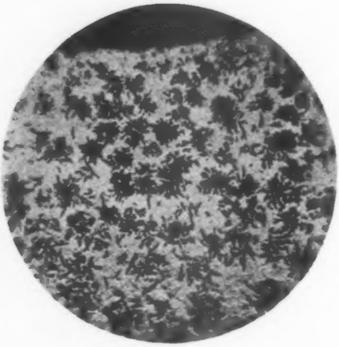

FIG. 37

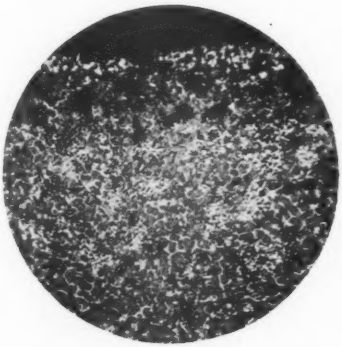

FIG. 38

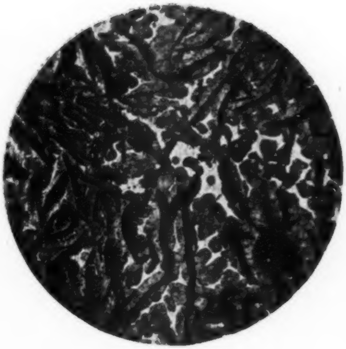

FIG. 39

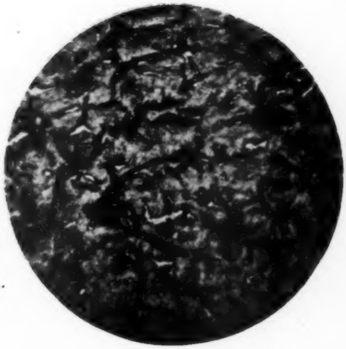

FIG. 40

FIG. 41

FIG. 42

THE FOUNDRY FOREMEN'S EDUCATIONAL MOVEMENT.

BY D. O. WILSON, NEWARK, N. J.

The great educational movement among foundry foremen in America and abroad must naturally be of considerable interest to foundry owners, and hence a few remarks to the point delivered at the Pittsburgh Convention of the Allied Foundrymen's Association will not be amiss.

Be it remembered, none of us have reached the point when we can truthfully say our education is complete. Doubtless you will bear me out when I hold that the more we learn of any subject, the more we realize how much there is to be learned, and how little we know of it.

And the foundry business is one of the arts which calls for continual study. Doubtless you are all familiar with the common by-word "sand artist," which is applied to molders. Well, after all, there is a great deal more in that phrase than most men who use it are aware of; and it is to educate and help each other understand the "Art" more thoroughly that the foremen's organization was first started, and is still kept on. It gives opportunity for the interchanging of ideas and talking over the thousand and one troubles which continually arise in the foundry.

In the first place, a man just so soon as he takes the foremanship of any shop, be it foundry, pattern, or machine shop, learns as his first lesson that he is alone in the sense that he cannot go to any of his men and ask them how he should do this or make that. Just as soon as the men realize that their foreman has to fall back upon them for assistance, from that time on they will start to take advantage of him, and in so doing, they are taking advantage of their employer. The results are obvious.

Now right here is where the foreman will benefit by his educational organization. He can either attend a meeting and bring out his difficulty for discussion, and all will learn therefrom,

or else he has the privilege of writing the secretary, who will obtain the necessary information for him, everything being kept confidentially throughout. It might be said here that the latter course, though admissible, is rarely used except where distance prevents attendance at a meeting, for the modern foreman has no hesitation in asking for advice or confessing his inability to overcome obstacles off-hand.

Take, for instance, a pattern which is brought into the foundry and it is required that the casting stand a certain pressure, and the metal has to be a certain thickness. It is found, after casting and machining the piece, that it is porous. Or, to use an everyday expression, "it leaks like a sieve." Such a case I have in mind and the foreman brought a piece of the casting to the meeting of the foundry foremen. After quite an interchange of thought and discussion, it was decided by several competent judges that the trouble lay in the mixture, that the graphitic carbon had to be reduced and the combined carbon increased. I learned from the foreman in question afterwards that the instruction received that night overcame his troubles. I might add, it also was a pointer to all the others who were present.

I recall another instance when a foreman presented a case which had baffled him and many others. It was that of a wheel which was not designed proportionally. He had lost quite a few. He was advised to place chills against certain parts and that done, I learned that his troubles were overcome. Many other instances can be cited of benefits devised by a thorough discussion of difficulties that arise in a foreman's daily routine.

Next comes the old familiar kick with the pattern maker, and how he has made such and such a pattern just this way because it is easier for him and saves time in his department, even though the foundry has to put in more than double the time which it actually ought to have taken in making the casting—simply because the pattern maker has little or no experience in foundry practice. But we have had pattern makers who did have knowledge of the foundry business come and deliver addresses dealing with pattern making and the foundry, and I can assure you the faults and failings of both trades were raked over and put forth in their true light, to the lasting benefit of all those that attended.

Again, our meetings have been honored by the attendance and lectures of members of the university faculties, among whom we count Professors Stoughton and Campbell, and also occasionally we see our esteemed friend, the secretary of the American Foundrymen's Association, who also gives us a talk on foundry subjects. By the aid of the stereopticon and practical demonstrations, ideas are firmly fixed in our minds to benefit us when the proper occasion arises.

Nights have been set apart for discussing the various elements entering into the composition of cast iron, as we have become quite familiar with our friend silicon, and the several trouble makers.

Many other topics have come up from time to time, such as cupola practice, how to charge properly, wind pressure, and melting with coal and coke. The advantages and disadvantages, etc. Also molding machinery with their good and bad points. How to run a shop to the best advantage. Cost keeping. How to best educate apprentices, and many other points of the greatest interest.

One subject which requires continual study and looking after so that the best results may be secured, is sand. Upon it depends a great deal of the success or the failure of the foundry business. Certain kinds of work are best made with certain sands. Coarse sand which will allow of the easy escape of gases, but which will yet hold well together or retain its life, to use a common phrase, is best suited for heavy work, and fine sand for light work.

These matters have also had their nights, and by a knowledge of such details, sound castings, free from scabs, etc., are more likely to result than if we remained in ignorance of such important points.

My advice to foundry foremen, pattern makers and machinists is, no matter where located, get together, form yourselves into societies and join in with the American Foundry Foremen who have been in existence for some years, and who are trying to benefit all who care to join with them in educational endeavor.

I assure you that you will be more than surprised by the benefits you will derive. We are living in an age of progress,

and if we are to keep up with the times, we must be in touch with what is going on about us.

We are past the stage when scrap and pig iron was put into the cupola at random because only iron was expected to come out. And to-day we must be on our guard and pretty nearly sure of what we expect to get out of the cupola, knowing exactly what goes in.

PROPOSED STANDARD METHODS FOR DETERMINING THE CONSTITUENTS OF FOUNDRY COKE.

Edited by H. E. Diller, Secretary Committee.

Discussion Invited.

Sampling.

Each carload of coke shall be considered as a unit. While the car is being unloaded, full length pieces of coke shall be taken at about equal intervals and a sample approximately the size of an egg taken from each end and also from the middle of each piece, until 25 to 40 pounds are obtained. Should it be necessary to sample from a stock pile, 25 to 30 pounds of sample, obtained as above directed, shall be taken for each fifty tons in the pile, care being used to get the piece from different places which will give a fair average sample.

Preparing the Sample.

Crush the sample between hardened surfaces, preferably of manganese or chrome steel, until all the material passes through a ½-inch mesh sieve. Quarter this; reserve one portion for moisture determination and crush the other portion until it will all pass through a ¼-inch mesh sieve, and again quarter down until about two pounds remain. Crush this until it will pass a No. 20 mesh sieve, and quarter down to about 20 grams. Grind this until it all passes through a No. 100 mesh sieve.

Moisture.

Dry one kilogram of ½-inch mesh sample to constant weight at 104° to 107° C. The loss in weight shall be calculated to per cent. moisture. Moisture shall be determined on the ground sample by getting the loss in weight when one gram sample is heated in an open platinum crucible of about 20 cubic centimeters' capacity for one hour at 104° to 107° C. The moisture on the ground sample shall be used to calculate the other results gotten

from the ground sample to percentages in the coarse undried sample.

Volatile Matter.

Cover the crucible containing the dried sample, with another crucible (either platinum or porcelain) of such a size that it will fit closely to the sides of the outer crucible, and its bottom will rest one-third (1/3) to one-half (1/2) inch above the bottom of the outer crucible.

Ignite 3½ minutes with the Bunsen burner and 3½ minutes with the blast lamp. Let cool, remove the inner crucible and reweigh the outer crucible with contents. The loss of weight is volatile matter.

Ash and Fixed Carbon.

Ignite the sample upon which the volatile matter was determined until all the carbon is burned, having the crucible open and inclined. The ash should be tested for unburned carbon by moistening it with alcohol, which will show black any carbon remaining. After all carbon is burned, the weight of the crucible and ash minus the weight of the crucible, gives the amount of ash in the sample.

The amount of fixed carbon is obtained by subtracting the weight of the crucible and ash from the weight of the crucible and residue from the volatile matter determinations.

Sulphur—Apparatus.

Crucible.—A soft steel or nickel crucible of about 40 cubic centimeters' capacity, the lid being perforated with a small hole for the introduction of the igniting wire.

Crucible Stand.—Any arrangement suitable for holding the crucible firmly in place and out of contact with the beaker during the peroxide combustion.

Determination.

To the dry crucible add first 12 grams of sodium peroxide and 0.5 gram of powdered potassium chlorate, then exactly 0.7 gram of coke (80 mesh) and mix thoroughly by means of a small spatula. Place the covered crucible on its stand in a 20-

ounce beaker containing enough water to immerse the lower half of the crucible.

Ignite the crucible contents by thrusting in, for a moment, a red hot wire through the lid hole. Wait two minutes or longer for the mass to cool somewhat, remove the stand and tip over the crucible on its side in the water. After the fusion dissolves, rinse and remove the crucible.

Acidify the solution with hydrochloric acid, then add ammonia in slight excess, filter and wash. To the filtrate add a drop of methyl orange, then hydrochloric acid from a graduated pipette or burette until 0.5 cubic centimeter in excess. Bring to boiling, add drop wise about 10 cubic centimeters of barium chloride solution, continue boiling at least fifteen minutes longer, and allow it to stand in a warm place for not less than two hours, filter, wash until the silver nitrate test shows no chlorides, ignite and weigh as $BaSO_4$.

$$\text{Grams } BaSO_4 \times 19.6 = \% \text{ Sulphur.}$$

PHOSPHORUS.

Ignite 5 grams of coke in a platinum dish or large platinum crucible until all the carbon is burned off, then add 10 cubic centimeters hydrochloric acid (1-1) and 20 cubic centimeters hydrofluoric acid and evaporate to dryness and ignite at a dull red heat. Fuse the residue with about 1½ grams of sodium carbonate and 2 grams of potassium nitrate. Cool, place the dish in a beaker of water and boil. Clean and remove the dish. Acidify the solution with hydrochloric acid, precipitate with ammonia, boil, filter and wash with hot water. Wash the filter with warm dilute nitric acid to dissolve the precipitate. Should it not dissolve, wash with warm dilute hydrochloric acid until dissolved. In the latter case, it will be necessary to evaporate to about 5 cubic centimeters, add 30 cubic centimeters nitric acid (1.20 sp. gr.); again evaporate to about 5 cubic centimeters and add 30 cubic centimeters nitric acid (1.20 sp. gr.). After heating the solution to between 70 and 90° C., add 50 cubic centimeters of molybdate solution. Agitate the solution a few minutes, then filter, and wash five times with a 3 per cent. nitric acid solution, and five times with a 0.1 per cent. potassium nitrate

solution. Transfer the precipitate and filter to the flask in which the precipitate was made. Add 30 cubic centimeters water, then $NaOH$ (N-5) from a burette until in excess, keeping the solution agitated. When the yellow precipitate is all dissolved add 0.1 cubic centimeter of phenolphthalein solution as indicator, and then titrate with H_2SO_4 (N-5).

c. c. (N-5) $NaOH$ — c. c. (N-5) H_2SO_4 x .0054 — % Phosphorus

To make the molybdate solution, add 100 grams molybdic acid to 250 cubic centimeters water, and to this add 150 cubic centimeters ammonia. Stir until all is dissolved and add 65 cubic centimeters nitric acid (1.42 sp. gr.). Make another solution by adding 400 cubic centimeters concentrated nitric acid to 1,100 cubic centimeters water, and when the solutions are cool, pour the first slowly into the second with constant stirring and add a couple of drops of ammonium phosphate.

WASTE SANDS IN THE FOUNDRY.

By S. A. Capron, Westfield, Mass.

To foundries in general, the securing of a sufficient supply of core sand and the disposal of waste sand are considerable items of expense. To most foundries, on account of their location, this becomes a serious problem. For this reason, any method of reducing the supply necessary has an equal effect on the problem of waste, and works a twofold economy.

I beg, therefore, to call your attention to core sand washing machines as a practical means of securing this economy by cleaning waste core sand and returning a large part of it as a new supply. The washed sand is free from all objectionable substances and satisfactory for use. Not over 20 per cent. of new sand is required to keep the total amount at the same quantity.

In operation, these machines involve a water process like that of the cinder mill, familiar in modern foundry practice. It is based on the natural separation of sharp sand from any foreign substances, which occurs quite generally in any slowly moving current of water. In these machines, the burnt core sand is first submerged in the water, and then by the action of the first series of flanges, is made to scour itself. This separates the sharp sand from the burnt core-bond coating that covers the grains. A second series of flanges then takes up the work and effects a further separation of the materials, the different specific gravities assisting in the process.

In its process through the machines the waste is now met by discharge buckets which pass under the lighter flowing waste and gather up the heavier material which consists of the reclaimed core sand. The final waste flows out of such a machine as a saturated solution of mud and other foreign matter, including some of the sand which has escaped the discharge buckets. This passes into a two-part settling basin where a still further separation takes place. From the first partition in this basin is obtained a sand which would be satisfactory for 50 per cent. of the cores in any foundry. The settling in the second partition

consists wholly of a very fine ground mud; but this is a very small per cent. of the total amount washed, generally not over 1 per cent. This is not only a much smaller proportion than is usually obtained, but is a much less objectionable product to dispose of than the ordinary black, dried dust.

The waste water can be used over again or carried direct to the sewer. The matter contained in this waste water is so light and fine that it takes several days for it to settle clear, at the end of which time, if the water is turned off and the waste dried, it will be found that 95 per cent. will pass through a "180 x 180" pick silk riddle. In the operation, 15 or 20 cubic yards of waste material can be handled in ten hours. The production of perfect core sand from this amount will vary from 80 per cent. to 90 per cent. The balance is recovered in the settling basin, and brings the total available sand up to about 95 per cent.

By washing worn molding sand, it has been found possible to separate 25 per cent. of good core sand from the fine grade of Albany stove plate. Machines of this kind will also handle sand which has been lying in the dump with equally satisfactory results, so that the percentage of loss can be made up from the waste of previous years instead of by the immediate purchase of new sand.

Core sand washing machines should run slowly, turning nine to fifteen times in a minute according to the grade of sand and requiring about three horse-power for this at these speeds. The water used is about 10 cubic feet to the cubic yard of waste handled, and an arrangement could easily be perfected whereby the water could be used over again if it were an item. The construction of this type of machine is such that it can readily be made a part of any design for a continuous sand moving unit, as it requires no regulation after starting the water in the sand; or it may be used as a unit by itself and the waste fed in at irregular intervals by any means, or shoveled simply into the hopper.

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These Papers are sold at the uniform price of 10 *cents per copy, or* $2.00 *per hundred. Send remittances to American Foundrymen's Association, Watchung, New Jersey, for prompt shipment.*

INSTRUCTION IN FOUNDRY CHEMISTRY.

By Herbert E. Field.

Part 4.

(*d*) *Phosphorus.*

Definitions.

Eutectic.—The eutectic, as applied to cast iron, is that portion of the cast iron which solidifies last in cooling. When cast iron cools, a portion of the iron, carbon, etc., crystallizes or solidifies out until the remaining molten mass reaches a certain composition. When this composition is reached, the whole of the remaining mass solidifies at once. This portion which solidifies last is known as the eutectic.

Segregation.—Segregation, as applied to cast iron refers to the separation of the different elements from the whole mass in cooling and their collecting together in one place. For example, phosphorus in large sections collects together in the point which solidifies last, generally the center. This collecting together is called segregation.

In Review.

In part 2 we studied the effect of carbon on cast iron, and learned that carbon was the controlling element and that the state of the carbon controlled the character of the iron. We found that the other elements present with the carbon in the iron exerted a powerful influence on the condition of the carbon and consequently upon the properties of the iron.

In part 3 we studied the effect of one element, silicon, on

cast iron, and found that through its action on carbon it softened cast iron; increased fluidity; and regulated shrinkage and strength. We considered the condition of the silicon in the iron and its direct and indirect effects on cast iron.

PHOSPHORUS.

General Effect on Cast Iron.

Cast iron must contain carbon or it would not be cast iron. Silicon is essential to regulate the form of the carbon in all the various grades of cast iron. Phosphorus is a necessity only in the lighter grades of cast iron, when fluidity and exactness of outline are necessary.

Phosphorus increases or prolongs the fluidity of molten cast iron; it makes cast iron weak and short; it may either decrease or increase shrinkage and hardness.

The Percentage of Phosphorus in Cast Iron.

Low phosphorus pig iron frequently analyzes as low as .015 in phosphorus, but the ordinary grades of foundry pig iron run from .2 to 1.50 per cent. in phosphorus. Castings could, therefore, be made of almost any phosphorus content desired up to 1.50 per cent., but, as will be noted later, its harmful effects necessitate its being kept as low as possible, and still have the molten iron possess the requisite amount of fluidity and the casting take sufficient exactness of outline.

Condition of Phosphorus in Cast Iron.

The condition of the phosphorus in cast iron has not been sufficiently investigated to warrant definite conclusions. It probably occurs in at least three conditions in solid cast iron, as phosphide of iron, as phosphide of manganese, and as a part of the iron eutectic. In molten iron, it apparently exists in a form similar to a dissolved gas.

Effect of Phosphorus on Condition of Carbon.

We have noted that the condition of the carbon determines the quality of cast iron. Phosphorus has a marked effect on the condition of the carbon. By prolonging the fluidity of the iron,

or rather the time it takes for the iron to set, phosphorus gives more time for the carbon to separate out as graphitic carbon. This action then tends to decrease combined carbon and increase free carbon.

The Effect of Phosphorus on the Amount of Carbon Present.

Phosphorus reduces the ability of iron to hold carbon in solution, so that most high phosphorus irons are low in total carbon. This is not only true of high phosphorus pig irons, but of high phosphorus cast iron. Irons high in phosphorus lose more, or rather absorb less, carbon in melting in a cupola than do low phosphorus irons.

Under "carbon" we noted the effect of the amount of "carbon" present in an iron so that the phosphorus by indirectly reducing this carbon, exerts an important influence on cast iron.

The Effect of Phosphorus on Iron.

Direct effect of phosphorus on iron is to cause it to assume large crystals, due to the fact that the phosphorus prolongs the cooling of the iron just as the iron is solidifying. This phenomenon is disguised to a certain extent by the action of the phosphorus prolonging the separation of carbon, but experience with steel with its small percentage of carbon has proven that this phosphorus has a direct effect on the structure of the iron itself.

Action of Phosphorus in Cast Iron.

When cast iron cools, the iron itself may crystallize out and leave what is known as the eutectic to solidify last. When phosphorus is present in excess, it forms a part of this eutectic, which surrounds the crystals of iron previously solidified. This eutectic solidifies later and in cooling causes strains in the iron which tend to make it brittle.

Phosphorus as a Promoter of Fluidity.

The principal beneficial effect of phosphorus is to increase fluidity, or rather to prolong fluidity. The temperature of the molten iron is not increased by the presence of phosphorus, but the interval consumed by iron in solidifying is much prolonged by the presence of phosphorus.

This property makes high phosphorus iron valuable in thin sections, as it fills the smallest crevices of the mold. Phosphorus is of inestimable value in ornamental castings when a clearness of outline is the all important factor. By prolonging fluidity, phosphorus gives time for all dirt and dross to rise to the top of the metal. Phosphorus is, therefore, a necessity to many foundries and would be a great help to all if it were not for the fact that it makes iron brittle, cold and short.

PHOSPHORUS AND ITS EFFECT ON STRENGTH.

Phosphorus makes cast iron cold, short and brittle, and liable to break under light shock. Castings which are subject to rough usage and which are liable to undergo shocks and strains, must, therefore, not contain high phosphorus. This is true also of castings which must undergo strains in cooling, caused by unequal sections. If a casting has a large and small section adjacent, the light section will set and contract first; when the large sections cool it will contract, and, if the phosphorus is high, it may crack the small section.

PHOSPHORUS AND ITS ACTION ON HARDNESS.

The direct action of phosphorus on cast iron is to harden; its indirect action is to soften.

We have noted that graphitic carbon softened iron, and that the longer the iron occupied in cooling, the more of the carbon will be found in the graphitic state. Phosphorus prolongs the cooling of the iron, and hence its indirect action is to soften the iron. If there were no carbon, phosphorus would harden iron.

PHOSPHORUS AND ITS ACTION IN SHRINKAGE AND SEGREGATION.

We have defined shrinkage as the drawing away from the liquid or plastic part of a casting, due to the contraction in an adjacent part of the casting which has already solidified. Phosphorus segregates in the heavier parts of castings, and there is generally more phosphorus in the parts of a casting which set last. This segregation of phosphorus in the larger section tends to keep those sections liquid for a longer time. This gives more opportunity for those parts of the casting which have already solidified to draw away from these portions and cause a shrink. On the other hand, phosphorus in prolonging the cooling, gives

more time for the separation of graphite, and hence tends to decrease shrinkage. The character of the castings determines which effect will predominate. In castings which consist of heavy and light section adjacent to each other, phosphorus may be said to increase shrinkage. In light castings of uniform section, phosphorus may decrease shrinkage.

MEMORANDUM ON THE STANDARD TEST BAR FOR CAST IRON.

By Dr. Richard Moldenke, Watchung, N. J.

At the Copenhagen Congress of the International Society for Testing Materials, the so-called "Arbitration Test Bar for Cast Iron" was fully discussed, and comparisons made of the practice prevalent in the several interested countries of the world. It will be remembered that the test bar in question is 1¼ inches in diameter, and 14 inches long, being broken transversely on supports 12 inches apart.

The comparison of practice showed that so far as the diameter of the bar is concerned, there is a general accord, foundrymen and users of castings having finally concluded that as large a bar as can conveniently be handled on ordinary testing machines is the one to adopt. Germany, Italy and the United States have adopted the 1¼-inch diameter, or metric dimensions very close to this. England, while quite favorably inclined has not yet acted officially on the subject.

In the original discussion of the subject in the United States years ago, it was decided to break away from existing practice where necessary, in order that the best results might be had, it being felt that a turning point had been reached making this action necessary. The committee having the matter in hand consisted of the foremost men in the cast iron industry of the country, and results have amply borne out the wisdom of the conclusions arrived at. Even at that time it was suggested that three sizes of bars be taken, to represent light, medium, and heavy castings. This scheme was not adopted at the time, as it was felt to be cumbersome, though offering theoretical and practical advantages. Germany, however, with characteristic thoroughness, adopted the plan for a time, but finally broke away from it, taking the single standard, in this, following the American example of getting a bar that would indicate the

quality of the metal used, rather than the specific test of the castings, as nearly as this could be done, without breaking them or cutting out coupons.

Further, the manner of preparing the test bar, seems to be in accord everywhere in its main features. Bars to be cast on end, in dry sand. Germany differs only in pouring from bottom up, whereas all the other countries pour directly into the top. German practice is undoubtedly the better one, though more expensive.

The radical difference in the several standards seems to lie entirely in the length of the bars for test. We break at 12 inches between supports. Germany makes it almost 2 feet, while Italy takes the distance only 6 inches. It was therefore suggested at the Copenhagen Congress that a series of tests be made in the several countries interested, with bars ranging from 6 to 24 inches between supports in breaking them, and from the results obtained that length be selected which will give the best all around values.

Mr. Walter Wood, of R. D. Wood & Co., the Chairman of the Commission on Cast Iron, took up this work for the United States, and reported at the last meeting of the American Society for Testing Materials. A short synopsis of the results is given herewith, in the hope that it might stimulate further investigations along the same line, and thus add to our sum of knowledge.

Three grades or classes of iron were experimented with. Silicon selected was around 1.50, 2.00, and 2.50 per cent., metal being taken in hand ladles from four-ton mixing ladles of the several irons in question. The diameters of the standard bars cast varied from 1.23 inches to 1.25 inches, and results were properly corrected. Both transverse and tensile tests were made, though it may be mentioned that the modern tendency is entirely against the use of the tensile test for cast iron, on account of the heavy errors in the work liable to occur when least expected.

The results were as follows:

ANALYSES OF IRON IN THE TEST BARS.

Grade	*Set*	*Si*	*S*	*P*	*Mn*	*C.C.*	*G.C.*	*T.C.*
	1	1.65	0.10	0.82	0.45	0.80	2.78	3.58
A	2	1.58	0.11	0.79	0.44	1.04	2.70	3.74
	3	1.49	0.11	0.80	0.44	0.86	2.85	3.71
	4	2.10	0.08	0.81	0.47	0.72	2.82	3.54
B	5	1.94	0.07	0.79	0.51	0.70	3.04	3.74
	6	1.88	0.065	0.79	0.44	0.73	2.85	3.58
	7	2.67	0.08	0.72	0.65	0.75	3.01	3.76
C	8	2.45	0.08	0.87	0.41	0.70	2.90	3.60
	9	2.36	0.08	0.86	0.38	0.75	2.81	3.56

TENSILE TESTS.

Grade	*Set*	*Lbs. per Sq. In.*	*Remarks*
A	1, 2, 3	25,600	Average of 9 bars.
B	4, 5, 6	24,370	Average of 9 bars.
C	7, 8, 9	24,660	Average of 9 bars.

The above being for 1¼-inch D. bars, it would indicate an excellent iron for the composition in question.

TRANSVERSE TESTS.

Modulus of Rupture in Lbs. per Sq. In.

Grade	*Set*	*12" span*	*18" span*	*24" span*	*Remarks*
A	1, 2, 3	47,100	45,600	44,700	Average of 9 bars.
B	4, 5, 6	45,500	43,200	39,700	Average of 9 bars.
C	7, 8, 9	45,200	44,900	44,000	Average of 9 bars.
Average,	1-9	45,930	44,570	42,800	Average of 27 bars.

The above would indicate a steady downward progression of the modulus of rupture for cast iron, as the span increases, showing that the test loses in accuracy as a consequence.

In order to get at the subject a little closer, ten sets were cast each of four bars, 1¼ inches in diameter and 26 inches long. These were broken on supports 14 inches, 16 inches, 18 inches and 20 inches apart. The composition of the metal was as follows:

Silicon, 1.90; sulphur, 0.08; phosphorus, .750; manganese,

0.65; combined carbon, 0.55; graphitic carbon, 3.10; total carbon, 3.65.

The average of the transverse tests on these bars gave the following:

Breaking Weight in Lbs.	14"	16"	18"	20"
Average of 10 bars	2,450	2,135	1,900	1,720
Modulus of Rupture in Lbs. per Sq. In.	44,000	43,800	43,800	44,100

From the above little can be judged. The difficulty remaining would seem to lie in the fact that no tests with spans as low as 6 inches are available. With such results, it would be possible to plot a curve showing the relation of the span to the modulus of rupture of the material, the turning point being found when too great a stiffness and consequent high results, change to too great a weakness, or possible lack of sensitiveness on the part of the test, on the other side. This point, when found approximately for the several classes of iron at issue, would be the desirable length of the span for a standard test.

There is need, therefore, of extending the above series of tests by supplying information with the smaller spans, and thus enable an international agreement on the length of the test bar for arbitration purposes to be finally selected, closing the subject until the time comes when further light on the complicated subject of cast iron may make it desirable to open the matter up again.

REPORT OF THE COMMITTEE ON INDUSTRIAL EDUCATION.

Your Committee on Industrial Education is able to report an increasing interest in the subject of trade and continuation schools. The public mind is becoming more receptive to the idea of spending money for industrial education in one form or another, and the large corporations which are devoting considerable money for the maintenance of schools of their own are enlarging and strengthening those schools because of the benefits derived therefrom.

During the past year the idea that for the present at least continuation schools upon the Cincinnati and Boston plan are preferable to the more expensive trade schools has been gaining many adherents. Several reasons may be found for this growing conviction in the value of continuation schools.

First.—The success of these schools in Cincinnati and Boston.

Second.—The visit, to this country last fall, of Dr. G. Kerschensteiner, Superintendent of the Schools of Munich, Germany, whose reorganized continuation schools are justly attracting the attention of the industrial and educational world.

Third.—That first class trade schools are expensive and can be maintained only in large cities or with the support of the State.

Fourth.—That trade schools necessarily reach but the comparatively few, and leave out of consideration the large mass of industrial workers who cannot or will not sacrifice the time to learn a trade; but who, nevertheless, are in need of some kind of industrial education.

Fifth.—In the minds of many educators as well as manufacturers, continuation schools offer a partial solution, at least of some serious problems in our national educational system and for which no other form of industrial education seems to be so well adapted to give relief.

During the past year the conviction has been gaining ground rapidly, that eventually the State, if not the National Government, must come to the relief of the industries in this matter of

industrial schools. Since it is seen more and more clearly that the industrial education of all the workers and not only a few of the best ones, has become a matter of necessity to preserve the industrial standing of the Nation, just as our common schools are considered necessary for the life of the Nation; therefore, the State should assume the burden of the industrial education of the masses similarly as it supports the common schools. In fact, New York and Massachusetts have made a beginning in that direction with Rhode Island and Wisconsin falling in line.

Our changes in economic conditions have required a change in our educational system and the only rational solution of the problem will eventually be found in the State organizing and sustaining a system of manual training, continuation and lower industrial schools, up to the sixteenth year of age of the pupil; and the Municipality maintaining trade schools to suit local needs. While this does not necessarily mean compulsory attendance up to sixteen years of age, it does mean close co-operation between the industries and school authorities, such as exists in Cincinnati.

To make such a plan effective, however, requires the earnest good will and co-operation of the educators, the manufacturers and business men, and of the workingmen themselves.

The desirability of using industrial education not only as a means to impart mechanical skill, but also to turn it into a helpful socializing agency may be illustrated by the following case:

In a certain large industrial concern which was generally considered immune from labor troubles, differences arose between the men and the management. Meetings were held by the men, committees were appointed to wait upon the officers and with a liberal use of good common sense and mutual forbearance the matter in dispute was amicably adjusted. Now, it can be easily foreseen that this occurrence is destined to mark a new stage in the relation of the men to the management in that concern; and is liable to do so in other concerns for that matter. Without any disposition of these men to join a labor union they have felt the strength of united action and are planning to form a permanent shop organization for the adjustment of grievances if any arise. At this stage of the proceeding we can perceive the usefulness and social-economic value of a broad industrial education, for admitting at the outset frankness, honesty and sincerity which

should mark all transactions between employer and employee in the adjustment of differences, it requires no great stretch of imagination to see that unless the men have had some primary training in economic factors, there may be friction in the course of the discussion for friendly adjustment of some grievance. For the men are not able to grasp the meaning of the economic forces which so often compel the industries of the country, the district, or the individual concern, to do certain things which are new and objectionable to the men, but cannot be avoided without present or future loss and injury to the business. Indeed, these would be injurious to the men in the long run, though they might gain the point at present. If, under such circumstances, the men, conscious of their power in unity of action, are not possessed of the necessary industrial intelligence which gives them insight into economic conditions, then the chances are that there will be misunderstanding, suspicion, friction, contention and no amount of mechanical skill and manual dexterity and mathematics, not backed by good will, common sense and industrial intelligence, will prevent both parties pulling in different directions.

What does industrial intelligence consist of? The sum and substance of industrial intelligence, which should be one of the most valuable achievements of a broad industrial education, gives a man the power to see beyond the immediate performance of the operation at which he is engaged for the time being. The power to see the relation of his skill and the results of his work to the success or failure of the concern he is working for, to the success or failure of himself and his fellow workmen; the power to see the intimate connection and interdependence between his careful or careless, his intelligent or unintelligent, honest or dishonest action and his personal welfare and the welfare of those depending upon him and the welfare of the community at large.

Industrial intelligence includes some knowledge of materials, ideas of their production and cost, ideas of the organization of a modern industry, ideas of the nature and extent of the business of the country, and a sense of duty and responsibility as a mechanic as well as a citizen. An education is of little value, when rated only by a purely commercial standard.

Such an education, based merely upon manual dexterity and mathematical precision, loses sight of the strengthening of the moral and intellectual foundation which underlies all human action, giving an understanding for the necessity of judicious application of the mental, physical and material resources which form the basis of the continued welfare of our national life.

If industrial education confines itself to the purely commercial aspect of the results to be obtained, as indicated by present tendencies, because of least resistance in that direction, then we need not be surprised if that education, appealing only to the selfish nature of the industrial worker, becomes a source of friction in times of economic stress and changes in the conditions of life of the nation and its industries.

In connection with this aspect of industrial education the question may be asked whether it would not be advisable to begin our industrial education lower down instead of following the traditional lines of literary education by beginning at the top. Forcing the boys into the public and technical high schools, under the plea that this is the most effective and the shortest way to produce commercial results, is liable to produce unexpected results. It makes the more expensive higher schools preparatory schools where they ought to be finishing schools. Let the average American boy once be surrounded by the high school atmosphere and college notions usually prevailing in these schools, so that he imagines himself to be removed a step above the common laborer and he will be much more liable to become a dissatisfied human being, than if the same boy had had his training in a well managed, broadened manual training, and equally effective, but cheaper, continuation school. During the past year your committee has had numerous opportunities to be useful and helpful to the industries in the interest of industrial education. The chairman of your committee has had occasion to speak in behalf of industrial education in the new school code recently enacted in Pennsylvania. At the Annual Convention of the National Education Association of 1910, in Boston, your chairman was given the opportunity to speak twice. He was likewise invited to address the Philadelphia Foundrymen's Association, the Roundtable Conference of Superintendents and Principals of Central Pennsylvania, the Faculty of the Industrial Department

of the Carnegie Technical Schools, and also the students of the same department of these schools. An invitation was also received and accepted by your chairman to address the Manual Training Department of the National Education Association at its 1911 convention at San Francisco. The topic assigned was: "The New Standards of Present Day Industrial Education in Europe." A synopsis of the address delivered upon that occasion is appended. Your chairman was also honored by being elected Vice-president of the Pennsylvania Branch of the National Society for the Promotion of Industrial Education. Flattering mention was made of the work of your committee in the December number of the Manual Training Magazine. These invitations and the correspondence carried on, during the year, by your committee indicate a growing spirit of co-operation upon the part of those interested in industrial education.

PAUL KREUZPOINTNER,
Chairman.

Appendix I.

Synopsis of Address delivered at *National Education Association Convention,* San Francisco, Cal., July 8-14, 1911.

Subject:—*The New Standards of Present Day Industrial Education in Europe.*

By P. Kreuzpointner, Altoona, Pa.

On final analysis of the present day organization, aims and tendencies of industrial education in Europe, we find the new standards aiming for mechanical skill, technical knowledge, insight into economic principles, civic efficiency and development of a sense of duty and obligation to onesself and to the community. New ideas about the cultural, the economic, and the social value of industrial education upon a broad socializing basis have become standards, perceiving in the broad industrial education of the masses a new social force economically beneficial to the industries and useful to the State. This as a civilizing agency and to conserve the mental, moral and material resources of the State for its preservation and for the best uses of the people.

In European countries the man, as a civic unit, receives first consideration so as to strengthen the machinery of the State.

In order to maintain these standards and to carry out such an elaborate program there is available a patriotic willingness to appropriate enormous sums for these industrial schools, a remarkable co-operative spirit pervading all classes of society when it comes to making sacrifices for the technical education of the people, and a democracy in the use of educational methods. which secures the widest distribution throughout the mass of industrial workers, of industrial intelligence, economic insight, and the conception of civic obligation and public spirit.

Are these new standards applicable in any form to our own industrial, social and economic conditions?

Are we prepared to make our coming industrial schools equally as democratic? As diffusive and varied in form? As suitable to local conditions and individual requirements as are the industrial schools of our European friends and competitors?

Appendix II.

Copy of a letter sent to a prominent Manufacturer, which is self-explanatory.

It affords me great pleasure to comply with your request to give you my opinion concerning your proposed plan of raising a sufficient sum by contributions from manufacturers in order to enable the National Society for the Promotion of Industrial Education to send out a field officer whose mission it should be to interest State and Municipal authorities in a well thought out plan for the introduction of Industrial Education.

While I have good reason to believe that a great deal of argumentation will yet be necessary to convince many people of the urgent necessity of industrial education for the masses of our industrial workers, nevertheless, I fully agree with you that the time for action has come in order that results may be produced. The question then is what shall be the nature of the plan the proposed field officer is to offer wherever he goes, and is it possible to prepare a plan suitable to most, if not all communities?

It would seem that with the difference of local industrial conditions, the heterogeneity of the population and the varying degree of social and economic development in different sections of the country it would be a very difficult matter to produce such a plan.

Since one field officer could not very well be sufficiently familiar with all conditions he would have to make his plan so general that much of its value and his effort would be lost. The success of the German industrial schools is in a large measure due to the flexibility of the law which gives individual communities freedom to adjust the school to their local needs in form and expenditure.

This democracy in the manner of organization and treatment of subject matter of the industrial schools in Germany, Switzerland, and Austria, is a feature which deserves our serious attention because of the aristocratic tendencies in our educational system, with the University as the final goal ever in view of the few to the neglect and detriment of the multitude who never go beyond the sixth, seventh or eighth grade.

This variableness in local industrial conditions, even greater with us than in any other country, and the vast extent of territory to be covered, would suggest the idea of a field officer for each State taken from among the members of the State Committees.

The advantage of such an arrangement would be found in the smaller territory to be covered and the greater familiarity of the field officer with local conditions. This would help to make him better acquainted with those to whom he could be of greatest assistance. Being of the State he would be recognized by the Legislature as a representative of the interests of the State and thus be helpful in shaping legislation favorable to whatever plans are best suited. A National field officer cannot do this so well unless it is intended to have the State field officers under the direction of a National field officer. This would be expensive, however. Again, unless the National field officer is of very high recognized standing and very tactful, he might not succeed in gaining the confidence and co-operation of the State branches and the value of his work would be diminished.

It appears to me the field officer, whether State or National, would meet with more success if he put less emphasis upon the pedagogical aim and object of industrial education and more upon its economic and social aspect. Business men, manufacturers and the vast majority of taxpayers are more receptive to arguments from the economic and financial standpoint. The educational aspect of industrial education they consider a matter belonging to the professional teacher. Moreover, the teachers in their conventions are constantly discussing the pedagogical side of industrial education and their efforts would be strengthened considerably by a persistent intelligent and authoritative presentation of the civic and business side of the question.

Before sending out such field officers the National Society for the Promotion of Industrial Education should put itself on record as to the most desirable form of industrial education under present conditions. With such a decision as a basis the field officer could go before the taxpayer and the manufacturer with what they may expect in results and in cost, with an economical or with a liberal expenditure, leaving the working out of details to local conditions and enterprise.

If the manufacturers and the people can be shown that the cheaper continuation schools serve an excellent purpose in preventing the fearful and expensive waste of the last two years and at the same time serve as a stimulus and preparation for specific trade education where it is desired, much of the present indifference and opposition would probably be overcome. Thus far the metal trades, needing the highest skilled mechanics, have led in the demand for skilled men, creating the impression with many that the expensive type of specific trade schools is the only type of industrial schools worth considering in trying to solve the vexed problem of industrial education in the United States, and do it in a hurry.

Upon the one hand this aspect of the problem has scared many people on the financial side of the question, and on the other hand has left out of consideration the necessary preparatory stage upon which to build efficient trade schools and to do something for the great number of those who do not need or do not aspire to the education of a first class mechanic. There can be such a thing as waste of time, money and the mental resources of the nation in education just the same as there is waste of time and money and of material resources in the production of goods. No greater service could be rendered to the people and to the industries by the National Society for the Promotion of Industrial Education than to bring home to the people the economics of effective and efficient educational methods and plans.

Delaying the establishment of industrial schools, lack of preparation of pupils whereby the advanced schools are obliged to do work and lose time that ought to have been done in the school below, cheap teachers, poor equipment are all sources of loss of time and money to the pupils and to the taxpayer, and a presentation of the money value of that loss to the public by the field officer would go further to stimulate public action than the recital of a pedagogic plan which might not fit local conditions. The following would suggest itself:

First.—For the National Society for the Promotion of Industrial Education to induce the State Branches to appoint a field officer for the State, this officer to be under the direction and pay of the National Society.

Second.—Have the State officer agitate for the creation, by

the Legislature, of a State Educational Commission where there is none.

Third.—For the State Field Officer to assist, in every honest way, in inducing the Legislature of the State to subsidize the establishment and maintenance of industrial schools.

Fourth.—To induce local industries, Chambers of Commerce, school authorities, municipal authorities and other local organizations to support manual training schools, continuation schools or such other forms of industrial schools most beneficial to the locality.

Fifth.—To agitate for the formation of local educational clubs, or societies, composed of employers, business men, mechanics and school men for the purpose of popularizing industrial education and to strengthen the position of the school authorities.

Sixth.—Much stress should be laid by the field officer upon illustrating the lectures and informal talks in order to reach the mind of the people more effectively.

If the various field officers would meet occasionally in general conference for the purpose of exchanging ideas and experiences the main points of the work could be unified and strengthened.

The annual reports of the field officers at the meeting of the National Society for the Promotion of Industrial Education would stamp the work of the Society as of practical value and bring the industrial and the educational interests closer together.

With many the conviction is growing that the industrial school of the future has to offer more than mere manual dexterity training, some drawing and mathematics. It is being felt more and more that the mechanical-technical education of the industrial school of to-day is too narrow for the complex civilization of this industrial age of world wide interests, and the manifold duties and obligations of the mechanic as a man and citizen which he is continually called upon to exercise.

With increase of density of population and decrease of resources competition will become keener and the economic pressure greater. This in turn will require the acquisition of more technical knowledge, and the application of science to every day affairs more than now. But technical and scientific refinement

are of little use unless there is a proper comprehension of sense of duty and responsibility to give proper attention and effective application to the technical means at our disposal.

The responsibility of the man in the mechanic is increased by the technical refinement of his work and the proper cultivation of this sense of duty and responsibility is an ethical problem, a problem which cannot be solved by drill in mechanics and mathematics.

May not the increasing carelessness, so frequently complained of in large concerns, requiring ever increased supervision and inspection of the men and their work; may not the frequency of accidents, be due largely to a flagging in the sense of responsibility, trusting too much in the infallibility of technical appliances, the financial and labor saving value of which is often exaggerated to such an extent that the belief is created as if technics and mechanics, mathematics and the drawing board could be made a reliable substitute for all human activity and responsibility.

Thus the intensity of application of technical and scientific knowledge at present and more so in the future, will require of the future industrial education of low as well as of higher grade, the recognition and treatment in its programme not only of mechanic-technical but also socio-ethical questions. Thus we can perceive how mechanical skill, technical knowledge, civic virtue and moral sense of responsibility are closely interwoven and dependent for their success upon each other.

And if industrial education is to give full value alike to the industries and to the communities, to the people, then it has to be so organized as to be able to approximately solve this complex problem.

Paul Kreuzpointner,
Chairman.

DISCUSSION OF MR. R. E. BULL'S PAPER ON OPEN HEARTH STEEL FOUNDRY PRACTICE.

MR. BULL.—I believe I should somewhat qualify what I have said in my paper about the chemical changes due to melting. Most of the metalloids are oxidized to a marked degree, and the manganese as well suffers from the same reduction. I should have included this element. But the percentage of phosphorus is increased somewhat, from what cause I have never definitely been able to determine.

DR. MOLDENKE.—I would like to ask Mr. Bull what his judgment is as to the largest quantity of very small steel castings that can be successfully poured in the open hearth process.

MR. BULL.—I am sorry I cannot intelligently give a direct answer to that question, as my experience has not been broad along that line; that is, with the making of a large number of very small castings. But it would, of course, depend largely on the possibility of gating several such castings together. If many small castings can be nested together in the same mold, the difficulties of successfully pouring them are reduced.

DR. MOLDENKE.—Do you think a small open hearth furnace would be preferable to a large one for a shop making small castings, generally speaking?

MR. BULL.—Undoubtedly, yes.

MR. STOUGHTON.—I would like to ask Mr. Bull if he has had any experience with tapping a furnace by means of a double-runner into two ladles to better provide for the casting of small work with all or a portion of the heat. This plan has been tried in some steel mills to reduce the time consumed in pouring ingots, by dividing up the heat. I will also ask Mr. Bull if he has had any experience in skimming the slag off the steel in the runner as the heat is tapped from the furnace, and whether such a plan overcomes the difficulties due to the presence of the slag. Also whether Mr. Bull has experimented with the addition of thermit and silicon to counteract the loss of heat and lower silicon content common to the last of the metal. I understand the use of a little thermit to warm up the metal and some additional silicon

introduced into the ladle after part of the metal has been poured into molds takes care of the condition you speak of. Do you believe such an operation would successfully overcome all the difficulties?

MR. BULL.—I have not had any experience with bifurcated runners, though I understand they have been successfully used in some mills. That plan might be applied with good results, I should think, in the pouring of many small castings from a large heat by reducing the pouring time. As to skimming the slag off the metal in the runner, I have had no experience. Whether this would be successful, I do not know. "I hae me doots," as the Scotchman would say. My efforts in this direction have been expended in trying to skim the slag off the metal in the ladle. We haven't had much success in this. There are many obstacles in the way. Lately we have been having some good results from experiments with "carbo" (petroleum residue). It now appears to us that we have found an effective and simple plan, but our experience has covered too short a space of time to speak with certainty. We had quite a supply of "carbo" on hand, bought for another purpose, and our furnace-man, recalling to mind the action of the "carbo" when thrown on the slag, on tapping a heat, threw into the ladle after the slag had drained from the spout a quantity of this "carbo," which produced a violent boil, sending most of the slag over the lip of the ladle like foam over a beer glass. (Laughter.) This was a very easy way of accomplishing what we had been trying to do mechanically for some time, but without success. It was found that twenty pounds of "carbo" acted very nicely in removing the bulk of the slag, and I now believe we have hit upon the easiest solution of the problem. It is not necessary to entirely remove the slag. We found by experiments that as little as two inches of slag on the metal has a very slight effect on the steel, and does not change the composition appreciably. But five to six inches of slag, which is the normal amount, does materially change the composition in most cases, of the last 1,200 to 1,500 pounds poured. I recall a heat, the manganese content of which at the start was .74 per cent., which finished at .47 per cent. This is an abnormal change. In most cases, the percentages of sulphur and phosphorus are increased, and the percentages of manganese and silicon are

reduced. The "carbo" has the double effect of removing the deteriorating slag and maintaining the desired temperature. I believe, Professor Stoughton, you mentioned one other point?

MR. STOUGHTON.—The use of thermit with silicon.

MR. BULL.—Their use would help, but they would not entirely take care of the difficulties. The addition simply of these two substances provide the proper temperature and silicon content, but of course have no effect on the phosphorus, sulphur and manganese.

A MEMBER.—Does the "carbo" raise the carbon content?

MR. BULL.—Not to exceed two points, which is not a sufficient change to make any material difference. Generally, the increase in percentage of carbon is found to be one point.

A MEMBER.—Is that in the basic process?

MR. BULL.—Basic.

A MEMBER.—What is carbo?

MR. BULL.—I am not very familiar with oil refining, but know that "carbo" is a residue obtained by refining petroleum. It is very useful for some purposes. It contains about 93 to 95 per cent. carbon. Some people call it "petroleum-coke."

MR. PUTNAM.—Mr. President, the speaker alluded to the chemical composition of steel regulating in some instances the necessity for annealing, and I should like to have him elaborate that point, if he will be so kind.

MR. BULL.—We can make a soft steel which in its raw state will considerably exceed the specifications of the American Society for Testing Materials, and whose ductility will satisfy ordinary conditions without annealing, at the same time meeting the requirements for tensile strength. This is done by making a low carbon steel with the other elements in proper combination, and without giving the castings any heat treatment whatever. This is what I meant by that statement.

A MEMBER.—Do you use the pyrometer in melting?

MR. BULL.—No, but I believe the pyrometer offers a good field, and better now since the radiation type has been perfected than has been possible in the past.

A MEMBER.—You have, I believe, three places on your heat report where temperature is mentioned. How do you get these?

MR. BULL.—They are gauged relatively by observation. Of

course it can be determined within reasonable limits, for instance, whether the metal is sufficiently hot when it is teemed.

A MEMBER.—Would it be possible to tap a portion of a heat and leave the remainder in the furnace to be tapped some time after?

MR. BULL.—No, it would not.

A MEMBER.—Are there any means of preventing hard spots in steel castings when you use charcoal in the risers?

MR. BULL.—Yes, and no. Rather, I should say, you cannot prevent occasional hard spots when using charcoal, for if sufficient quantity of this substance is used, and the casting proper does not quickly chill, the steel will certainly absorb some of the carbon in the charcoal. Much better results will be obtained by using "Little Devil" cans of thermit. Understand, I am not selling thermit. (Laughter.) But this compound produces a better feeding action than coke or charcoal, without causing hard spots.

A MEMBER.—How long does it take you to pour your heats?

MR. BULL.—Forty-five to fifty minutes.

DISCUSSION ON CUPOLA PRACTICE PAPERS.

By Mr. P. Munnoch and Mr. R. H. Palmer.

A Member.—I have been greatly interested in Mr. Munnoch's paper, and particularly in that portion relating to the increase in hardness due to sulphur. I agree that this will happen to some extent, but would like to know more about the quantities.

Mr. Munnoch.—That will depend upon circumstances. In some cases, in melting small material, we find a larger increase in sulphur than in handling heavy materials. It would be a difficult matter to give definite figures.

Mr. Palmer prefaced his paper by the following remarks:

"From the chemical analysis of the various grades of iron we learn the quantity of each element they contain, and by combining different amounts of the different grades, we are enabled to make mixtures suitable for various classes of castings. But, in order to obtain the desired result in the castings, intelligent cupola management is necessary to melt the iron satisfactorily and economically.

"When making up the mixtures, in modern practice, some knowledge of the effect of the different elements is necessary, and in melting the iron in the cupola, a knowledge of how they are affected is also essential.

"On the quality of the iron in the castings as well as on the workmanship displayed in their production depend the demand for and sale of the foundry output.

"All castings which appear perfect are not found to be so on machining, and the cause of the fault in the imperfect casting is at times not to be found in the mixture of irons, nor in the workmanship displayed in molding, but can be traced directly to imperfect, faulty cupola management when melting the iron.

"It is said that each locomotive, ship and engine has its peculiarities, and I believe the foundry cupola is constituted similarly. In having handled many styles and sizes of cupolas, I

have found each to have an individuality, or peculiarities, and in order to melt the iron satisfactorily for the class of castings desired a study of the every-day practical working of the cupola was in order to be able to do the right thing at the right time.

"We often remark on the knowledge of detail in manufacturing possessed by some men, and realize that it is their ability to quickly and correctly grasp these details that has given them success.

"There are many points in cupola management which seem trivial to the onlooker, but have a very important bearing on successfully running off the day's melt and producing the quality of iron desired.

" 'Eternal vigilance is the price of safety' holds peculiarly in the foundry."

At the conclusion of his paper Mr. Palmer added:

"You must have very favorable conditions if you can follow the practice of getting 10 to 1 or 12 to 1. There are days when I do not get more than 5 to 1. Some days I get 9 to 1. I to-day am running a 72-inch cupola, but not to its full capacity. Perhaps I am running 45,000 pounds; our heats may run anywhere from 30,000 up to 60,000, and, of course, the greater amount of iron I am melting the higher the ratio.

"In charging the mixtures I arrange to melt the most particular mixture first, because I can obtain in the castings the mixture of iron that I want with more certainty.

"When I first became cupola foreman (and in those days, along in the 70's, we did not have trade papers) and wanted to know some things about melting iron and went to a man in our locality who was supposed to be the leading foundryman, he said, 'My dear Palmer, experience will have to be your instructor.' Gentlemen, I ask you one thing, when a young man comes to you for information don't turn him down, give him the information he asks for."

Mr. Walker.—I should like to ask Mr. Palmer why he sometimes gets 5 to 1 and sometimes 10 to 1.

Mr. Palmer.—I should have said that it depends altogether on the size of the cupola. For instance, suppose you take the bed of a cupola in a 48 or in a 72-inch (there are times I am

called on to use either size), it does not make any difference how much iron I have to make, I must have the bed charge of my cupola above the upper tuyers. Suppose I have a charge of iron that may be 3,000 pounds, I put that on top of the bed charge of coke. Suppose the next charge that is coming is a basic iron of an entirely different class. I want to separate these two. I charge more coke between them than if I were melting one class of iron. I want to separate them because the last of the one charge and the first of the other will mix. In that way, of course, I am using more coke in proportion to the amount of iron I melt, and hence the lower ratio.

A MEMBER.—Do you gauge the proper height of the bed by the time it takes to get the first iron after the blast is put on?

MR. PALMER.—Not altogether. For instance, I find when our cupolas are working in good shape that it takes somewhere in the neighborhood of 10 to 12 minutes, if I charge a cupola normally. In the heavy work we often have to hold the cupola longer than we want to before we put on the blast, hence more coke. My practice is to charge the cupola and let it stand one-half hour before I put on the blast, and then it takes about 12 minutes. I do not like to see the iron start running too soon.

In putting what I think is the right amount of coke above the upper tuyers, I have a rod of iron with a crook above and a crook below. I put in coke enough to bring it about 26 inches above the upper tuyers.

If I have a new coke come into the yard and I weigh some of it and find it light, I find on putting on that 26 inches, and the bed charge on it, that the iron starts pretty quick, I come to the conclusion that the coke hasn't carried that charge as I wished it would. It has settled down, and I find that a low bed starts melting quicker than with the bed high. I would rather have the bed a little too high than too low.

PRESIDENT SPEER.—The Chair would like to ask Mr. Palmer if he has found trouble with the conditions of the atmosphere, that is, the climatic conditions?

MR. PALMER.—I find this on some days—I would say when there is sort of a damp atmosphere, perhaps not raining, but pretty close to it—I think I can melt faster than when it is a clear, bright day.

President Speer.—There has been a great deal of discussion as to whether the weather conditions had anything to do with the melting. I believe that the majority of chemists say that it has not anything at all to do with it.

Mr. Ryan.—I should like to ask Mr. Palmer if on that damp day he spoke of, he believes it is because of the weather or that the belt grips tighter. Are you direct connected or have you the belt connection?

Mr. Palmer.—I am belt connected. The belts on the fan certainly have an effect on the melting.

Mr. Smith.—Do you use a double row of tuyers, and do you use your two rows when you run?

Mr. Palmer.—I suppose what you have reference to is the fact that with a comparatively small heat you would prefer to shut off the upper tuyers. My cupolas are not arranged so that I can do this. I am obliged to use the two rows of tuyers. It has been my practice to close the upper tuyers in a cupola when I had a comparatively small amount to melt.

Mr. Smith.—The reason I asked the question is we used the double row for a long time, but we found we could melt up to 100 tons a day without using the upper row. We have found it is necessary to make a higher bed with a double row.

Mr. Palmer.—When a man has a double row of tuyers it means an additional height of bed. Have you high tuyers from the bottom or low tuyers?

Mr. Ryan.—About 12 inches.

Mr. Palmer.—I have on my 72-inch cupola about 14 inches, but I slag it, and in melting about 12-ton heats I use limestone. There would be enough slag accumulating so that it has to be tapped, and I open it up and then it will take care of itself. I charge about 20 pounds of limestone to the ton; I might have a limestone to-day that would do very nicely at that rate; again I might have to use 60 pounds. The 48-inch cupola requires more limestone than the 72-inch in proportion to the amount of slag made.

A Member.—Do you keep your coke covered?

Mr. Palmer.—We simply unload it from the car right in the yard, and it is exposed to snow and ice.

Mr. Warren.—Do you have the experience with this small cupola that the slag adheres above your upper tuyers?

Mr. Palmer.—Yes, sir; I have.

Mr. Warren.—What have you done to remedy it?

Mr. Palmer.—I said every cupola has its peculiarities. I have a little 24-inch one that certainly is "cranky," and it has bothered me for some time in running 4,500 pounds heat. I could run 4,000 all right, but when I ran up in the neighborhood of 5,000 pounds I got stuck, and I found this, that there is such a thing as charging too much limestone and making too much slag. In the first place, if you put in too much limestone, you are going to cut the lining of your cupola. Because, after you put in enough so that the limestone takes care of the sand, the excess is going to work on something, and that is the face brick. I found further I had too much blast, and I reduced this. I have to use the foundryman's method, putting up my hand and feeling the blast. I should say I have put a 5-ounce blast on that little cupola. But in regard to charges of the small cupola, you want to be very careful about their size.

A Member.—Mr. Palmer speaks of running the iron for the more particular work through the cupola first. I should like to ask him if he rejects the first ton obtained or does he consider it pure enough? We reject two or three tons off the first iron —we don't think it is good enough, as we build textile machinery.

Mr. Palmer.—To be honest in answering that question, I can only say I used to reject perhaps 400 pounds. It is claimed that the first iron running is a little higher in sulphur. I am using coke that was analyzing 1.10 in sulphur. All this only shows that different men have different experiences. For the last five or six years I have observed, whether the cupola is little or big, high or low, if you only take the precaution to get the iron at the right time, you get the desired results.

Dr. Moldenke.—I have never found a cupola which had special peculiarities. The bed charge must be just the right height, and that will vary with the different classes of coke. Normally, with the bed burned through, you should get first iron in from 8 to 10 minutes. You must put in mighty small charges to get the best results. The trouble is that if you have a great big bed you think you must have a big first charge. I will give

you an instance. Last week I was called into a foundry where the complaint was that they had cold iron and trouble all the time. I found this state of affairs:—8,000 pounds first charge, the other charges 3,000 pounds. No wonder there was trouble. It came entirely from burning the iron, simply because of the first big charge practically all the metal was melted at the wrong point. As fast as the coke is burned away there should be more coke to replace it. There is one point in the cupola where you get the right result. If you melt above or below it, you do not get the best results. In the foundry in question, after they reduced the first charge to the weight of the others and had the proportionate amount of coke between them, they had iron running that looked like snow; it was so hot. If you can get your melting practice right your troubles will cease; but, unfortunately, nine-tenths of the foundries do not know how to melt iron properly.

MR. ALLEN.—You may remember, Dr. Moldenke, a letter and some samples we sent you from Barry, Massachusetts. The trouble there was we were melting too heavy charges. I changed the practice and I certainly liked the way the iron appeared, but we still had the same trouble. The metal seemed to come much nicer, and I still wonder where I was at fault.

DR. MOLDENKE.—Unfortunately, you never wrote me afterwards, so that I could help you. I was called in some time ago by a foundry where I found that in charging the cupola they were placing in the heavy stuff against the lining of the cupola and the sprues, or light material, in the center. Here the melting was 1 to 16 on the outside and 1 to 5 in the center of the cupola. There are so many things that can make your practice weak in some direction. I have often seen the first iron come in five minutes. Here you are down so low in the bed that you are liable to keep on working too low in the cupola, and will burn your iron.

There was considerably more of the discussion, but owing to the noise of the adjoining exhibits the stenographic notes were too confused to be of any value.

DISCUSSION ON MR. C. H. GALE'S PAPER ON TITANIUM IN MALLEABLE.

Mr. W. D. Alexander.—We are starting to experiment with titanium. We have already made some preliminary tests. On the strength of these we now have under process some 200 treated and 200 untreated bars, to be used in comparative tests to learn the best possible percentage of titanium to use.

On the first we made a six-day test, pouring ten bars untreated and ten treated each day. The treated bars contained an alloy addition of 0.47 per cent. The second day, test bars contained 0.75 per cent.; the third day, 1 per cent.; the fourth, 1¼ per cent.; the fifth, 1½ per cent.; and the sixth, 1¾ per cent. The alloy contains about 10 per cent. titanium.

On an upset test of bars a 6-inch bar upset placed vertically on an anvil and held by a pair of tongs ½ inch in width, the implement being a 10-pound sledge wielded by an intelligent man who was instructed to regulate his blows as uniformly as possible, we obtained the following results:

Bars treated with 0.47 per cent. showed an aggregate percentage in their favor of 105 per cent. On the bars treated with 0.75 per cent. there was shown an aggregate in ten bars of 65.6 per cent. in favor of the treated bars.

The first day's treated bars, all showed stronger. That is, the length of butts expressed in per cent. of six inches was in their favor in each bar.

On the second day one of the untreated bars showed a slight indication of strength in its favor. The percentage being stronger in one bar.

On the third day's test, the bars containing 1 per cent. of the alloy, the untreated bars showed a percentage in their favor of 10½ per cent.

On the fourth day, with 1¼ per cent. alloy, the untreated bars showed 69.1 per cent. in their favor.

The fifth day, the bars treated with 1.5 per cent. of the alloy,

the untreated bars showed an aggregate percentage in their favor of 59.4 per cent.

On the sixth day, the bars treated with alloy containing 1¾ per cent., the untreated bars showed strength in their favor of 128.2 per cent. All bars showing stronger.

As a result of this test we poured 100 bars and treated them with 0.4 per cent. of the alloy, and followed it immediately with 100 of those bars, untreated metal, both poured about the middle of the heat; the ladle was pre-heated, and the alloy ground up and dropped in.

The second day, we poured 100 bars containing 0.6 per cent. and 100 bars untreated. These bars are now in the anneal, and we hope to be able to determine conclusively just what proportion of the alloy from which we could obtain the best possible results. We believe that from one-third to two-thirds of 1 per cent., or from 0.4 per cent. to 0.6 per cent. of the alloy would benefit castings, especially a large casting, such as valves and heavy trunnioned castings. We think it will possibly strengthen them, and we hope it will prevent possible blowholes in heavily cored castings.

MR. WEST.—How did you make your additions?

MR. ALEXANDER.—In the hand ladle, at the furnace—caught it from an air furnace. We are very much interested in this subject.

The tests in detail referred to by Mr. Alexander are, as follows:

No. 16.

Treated with 0.47 per cent. of Alloy			Untreated.		
Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.	Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.
3.00	50.00	10.42	3.625	60.42	....
2.875	47.92	8.34	3.375	56.26	....
2.5625	42.71	17.71	3.625	60.42	....
2.50	41.67	14.58	3.375	56.25	....
3.625	60.42	12.73	2.9375	47.69	....
3.4375	57.29	9.60	2.9375	47.69	....
2.25	36.50	11.19	2.9375	47.69	....
2.3125	38.56	6.23	2.6875	44.79	....
2.26	36.50	8.29	2.6875	44.79	....
2.25	36.50	6.21	2.5625	42.71	....

This shows 105.30 per cent. in favor of the *treated* bars.

No. 20.

Treated with 0.75 per cent. of Alloy.			Untreated.		
Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.	Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.
3.875	64.58	1.04	3.9375	65.62	....
3.00	50.00	12.50	3.75	62.50	....
3.00	50.00	9.37	3.5625	59.37	....
2.9375	48.96	7.29	3.375	56 25	....
2.6875	44.79	....	2.5625	42.71	2.08
2.3125	38.54	15.69	3.25	54.23	....
2.3125	38.54	7.29	2.75	45.83	....
2.4375	57.29	3.13	3.625	60.42	....
2.50	41.67	11.46	3.1875	53.13	....

This shows 65.69 per cent. in favor of the *treated* bars.

No. 21.

Treated with 1 per cent. of Alloy.			Untreated.		
Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.	Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.
2.875	47.92	....	2.875	47.92	....
3.50	58.33	4.17	3.75	62.50	....
3.25	54.25	....	3.125	52.08	2.17
3.375	56.25	....	3.1875	53.13	3.13
3.3127	52.08	....	2.9375	48.96	3.12
3.00	50.00	....	2.625	43.75	6.25
2.6875	44.79	....	2.6875	44.79	....

This shows 10.49 per cent. in favor of the *untreated* bars.

No. 22.

Treated with 1.25 per cent. of Alloy.			Untreated.		
Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.	Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.
3.625	60.42	....	2.6875	44.79	15.63
3.25	54.23	....	2.50	41.67	12.56
2.6875	44.79	....	2.625	43.75	11.04
2.3125	38.54	....	1.6875	28.12	10.42
3.25	54.23	....	2 0625	34.37	19.86
2.125	35.41	....	2.125	35.41	....
1.6875	28.12	....	1.625	27.08	1.04
2.00	33.33	....	1.75	25.83	7.50
1.75	29.17	....	1.6875	28.12	1.05

This shows 69.10 per cent. in favor of the *untreated* bars.

No. 24.

Treated with 1.5 per cent. of Alloy.			Untreated.		
Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.	Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.
3.50	58.33	....	3.00	50.00	8.33
3.125	52.08	....	2.625	43.75	14.56
3.0625	51.04	....	2.75	45.83	5.21
3.0625	51.04	....	2.75	45.83	5.21
2.875	47.92	....	2.5625	42.70	5.22
2.6875	44.79	....	2.625	43.75	1.04
2.625	43.75	....	2.625	43.75	....
2.375	39.58	3.12	2.5625	42.70	....
2.50	41.66	....	1.875	31.25	10.41
2.50	41.66	....	1.75	29.16	12.50

This shows 59.36 per cent. in favor of the *untreated* bars.

No. 27.

Treated with 1.75 per cent. of Alloy.			Untreated.		
Actual Length of Butt. Inches.	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.	Actual Length of Butt. Inches	Length of Butt expressed in per cent. of 6 ins.	Per cent. in favor of Treated Bar.
4.25	70.83	....	2.875	47.92	22.91
4.25	70.83	....	2.75	45.83	25.00
3.4375	57.29	....	2.9375	48.96	8.33
3.25	54.23	....	2.6875	44.79	9.44
3.1875	53.13	....	2.625	43.75	9.38
3.25	54.23	....	2.625	43.75	10.48
3.125	52.08	....	2.5625	42.70	9.38
2.75	45.83	....	1.6875	28.13	17.70
2.5625	42.70	....	1.625	27.08	15.62

This shows 128.24 per cent. in favor of the *untreated* bars.

The average composition of the bars in question can be taken at

Silicon	0.85
Phosphorus	0.175
Sulphur	0.043
Manganese	0.248
Comb. Carbon	0.07
Graph. Carbon	1.69

DISCUSSION ON MR. E. A. CUSTER'S PAPER ON THE PERMANENT MOLD.

MR. FULLER.—Mr. Custer's report of continuous melting seems a very excellent one—but Mr. Custer, you do not mention the fact as to how you slag the cupola?

MR. CUSTER.—Fifteen pounds to 600 pounds of iron. It can be slagged on the bottom.

MR. FULLER.—Another point is rather contrary to reducing charges of coke and iron. I note that you found it necessary to increase, after you started.

MR. CUSTER.—I don't know what that was due to. The iron got hotter and hotter, and we don't like hot iron in permanent mold work. The colder you can pour it, the more it gives you time to pull the casting from the molds, and the iron is less liable to chill and fills up all the corners better.

MR. FULLER.—I understood you to say you started with 250 pounds. First, you said that better result was secured with small charges?

MR. CUSTER.—Yes. We started off with 250 pound charges; we ran about four hours and then had to come nearer to the bottom and hence go on large charges. We, however, added anthracite to the fuel used and thus kept our melting point right.

MR. SCHWARTZ.—Will you explain what your experience has been in running castings with thin sections, as compared with heavy work.

MR. CUSTER.—The question arises naturally why if you can make a thin section casting and set it almost instantly, doesn't it require a longer time to set a thick casting?

Now, when we make a mold of quite a heavy weight, and hence larger chilling capacity, we make it for the purpose of extracting the heat from the molten metal instantly.

If we set a 1/4-inch section, we do not chill it instantly. If it is 2 or 3 inches thick, we set 3/8 on the outside and can then take it out of the mold. Then the iron inside is beginning to swell, a condition due to the harder outside skim, and it turns on

itself and makes an even, fine grain; so, the time occupied in taking a large casting out, so far as chilling is concerned, is the same as a small one. That will be shown in the foundry outdoors here every day we run. As the iron sets it swells, and you do not need to worry about a thick casting if you have a thick enough skin on the outside, and you can take it out as soon as that skin is formed.

MR. KENT.—There has been some discussion in regard to dumping out the casting too hot, what result has this? Does it have a tendency to chill the casting?

MR. CUSTER.—That is a fact that has puzzled me. I don't understand why it is so. We have a mold whose temperature is 300° F., and if the metal poured is in a few seconds too long it will chill. And then try low heat, put the molten metal in with the mold at a temperature of 30°, 40° or 20° F., it will not chill. I don't know why, but it will not chill it.

MR. WEST.—I do not know whether you have experimented any in reference to obtaining what would be the contraction of the casting just at the moment of solidification. The point I wish to illustrate is in my own work. Recently I experimented with chilled car wheels, and I am anxious to know what would be the contraction of the wheel soon after it solidified? I found in the casting of the chilled car wheel the contraction soon after solidification was about 25 per cent. of what would be the total contraction when the wheel was cold.

MR. CUSTER.—We will show that in a little car wheel we have in mold. We take it out before any contraction sets in. In other words, for a car wheel, if it wants to come out soft it will be dumped out at once and probably no contraction has set in. When you set it too quickly you will find that the car wheel fills every portion of your mold. It cannot be drawn out and stand on edge; yet it will take a chill on the upper surface. Just a thin skin on the outside sufficient to hold it together.

I will be very glad to show that to you at any time. You can follow that up better in a permanent mold than a sand mold. And the permanent mold lasts much longer.

PRESIDENT SPEER.—Mr. Custer, I would like to ask what effect, after a casting has been made, the oil coating on the mold will have on it?

Mr. Custer.—President Speer has asked an interesting question. You have all heard it. Take the ordinary casting and make a small gear (which we call for tool work), take that out at bright yellow heat and drop it into cold water and it will change the combined carbon to one-half, where it will only be about 2/10 if allowed to cool slowly. That casting will be as hard as chilled steel; you can cut glass with it, yet it will not be white but gray. If you drop it in oil, it will only close the grain, even softer than if allowed to cool slowly. If you take that same casting out at bright red or cherry, it will drop the combined carbon a little and will not harden so much when put in water. The oil has no effect on it at all except to soften the grain slightly.

Mr. Campbell.—If you make a chilled wheel, what would it do to oil it?

Mr. Custer.—We are not wheel-makers. The practice has been to oil chill wheels, we know. It produces a very good wheel, but whether it produces a better wheel with or without the oil, I do not know. We never oil our molds at all.

Mr. Brown.—Have you, Mr. Custer, in your experience ever had any trouble in taking a two- or three-inch sectional casting out of the mold, on account of its expansion?

Mr. Custer.—No; the shell I have is always sufficient to hold it up, in usual cases; but I must say, too, yes, we have had some experience of that kind. We have taken them out a little too quickly and broken the shell and poured the iron on our feet, but that does not matter much. (Laughter.)

Mr. Horne.—Have you trouble in finding many blowholes in castings?

Mr. Custer.—Yes, certainly. That brings us together on a subject we are all interested in. With an iron high in sulphur and high in manganese, it is pretty hard to prevent blowholes in that casting, especially in that portion of the casting where you cannot employ risers. We get away from that by building a trap in our gate.

Now, we can also produce various effects in the casting that do not make the casting any too good. For instance, we can fill that casting full of little shot. We don't like to do it but we can

do it. We can do that easier than bring the casting out perfectly clear, though, of course, we always prefer to have the casting clear.

Now, the only explanation of this that has been furnished you was by Mr. Pilkin, who watched through the floor hole and he saw little globules splash up and fall in the mold, and when he noticed this he found a little defect in the casting; but when there was a trap provided there were no shot in the casting. So all you need to do if you want to get the shot in the casting is to pour the metal into the mold with a splash.

But you will get blowholes if you use an iron that will make blowholes, certainly. It is only a question of the molten iron.

One thing about that is the fact that manganese is a great hardener and is not a fit or good thing for a permanent mold casting; it is good for a sand casting, but when you come to put the permanent mold in combination with manganese it becomes an extremely bad thing. Manganese to a mold is exactly what high sulphur is to a sand casting. I do not like it.

DISCUSSION ON MR. THOS. D. WEST'S PAPER ON GAS CAVITIES, SHOT, AND CHILLED IRON IN IRON CASTINGS.

MR. SLOCUM.—I want to say to begin with, that Mr. West's is the clearest exposition of the troubles caused by cold shot that I have ever heard of, and I should certainly commend it to foundrymen as a means of eliminating lots of their troubles by following out and practicing the explanations and suggestions he has given.

My particular query is, that in my experience, which was with high chilling iron and iron carrying about an inch chill or a little less, we frequently have a little of this trouble and sometimes attributed it to the fact that the molder in starting to pour allowed the iron to splash just a little,—as Mr. West has stated, and perhaps because the ladle was a little too full,—and we considered that as criminal practice. I want to get Mr. West's opinion as to whether we were on the right track in including that as one of our genuine difficulties, or whether it was caused by something else.

MR. WEST.—As near as I can understand you, you are correct in that proposition. You will notice in my paper I refer to where holes are in gray iron that I attribute them largely to the defects in molding; but where we get a chilling or very hard iron and one that solidifies quickly, then there is not the opportunity for the escaping of gases or little defects that is given in an iron that is longer in solidifying.

DISCUSSION ON MR. H. F. STRATTON'S PAPER ON THE APPLICATION OF LIFTING MAGNETS TO FOUNDRY WORK.

A MEMBER.—I would like to ask Mr. Stratton if he finds that in the use of the magnet in passing over the foundry floor, with chains and things of that kind lying around, there is any inconvenience as a result; and would not that affect the action of the magnet in any way? Also, has Mr. Stratton some figures about loading pig iron by hand? The average cost is to me, say 7 to 10 cents.

MR. STRATTON.—In regard to your first question, passing the magnet over the floor, it would not pick up chains or bars unless they came within the zone of its active influence, which for this material would be something like a foot from the bottom of the magnet. It is not a permanent magnet, it is an electric magnet, and any time you do not want it to pick up things you only have to de-energize it. Only when the operator wishes it to exercise the function of picking up articles does it do so.

In regard to the second question, I am free to admit I have no actual knowledge except what I have gained in six years of manufacturing and selling magnets. Regarding the case of hand labor, the figure of 10 cents a ton was given me by a gentleman who devotes all his life to considerations of foundry costs, being on one of the largest foundry trade papers.

I have frequently had this question asked of me, at the time when I was actively selling magnets, and told that sometimes people were handling pig iron at 6 cents by hand labor. It was invariably a matter of congratulation when that figure had been obtained.

I also found it was very frequently true that foundry managers did not definitely and accurately analyze the cost of unloading by hand, when the pig iron was not put on a tonnage basis. In two or three concrete cases that came to my mind they figured out certain figures when their men were energetic and were working all day, but those figures did not always obtain

because frequently the men were idle because of cars not being available or some other reason.

I do not intend to convey at all that 10 cents is a correct figure; it is a figure that is an assumption on my part, but it is the nearest figure that I could obtain. In my paper it is my hope to have outlined a method of making these estimates, so that you can make your own individual determinations. Anything that may be in the nature of an overstatement based on the too high cost of handling by hand, I really believe is sufficiently compensated for by the economies resulting from the incidental advantages I have mentioned, and I know of particular cases where these have been of very great importance. Gentlemen have said to me, for instance, that even if it were on a par, the cost of handling by hand and by magnet, they would very gladly put in a magnet because of the elimination of labor troubles. In some cases this is a very vital question.

DISCUSSION ON MR. C. V. SLOCUM'S PAPERS ON TITANIUM IN IRON AND STEEL.

MR. G. L. NORRIS.—I should like to call attention to a chemical inaccuracy in Mr. Slocum's comparison of the relative value of titanium and vanadium as deoxidizers. Mr. Slocum has assumed the reaction of vanadium and oxygen to result in the formation of V_2O_3. This is not correct, as vanadium combines with oxygen to form the oxide V_2O_5. Now using Mr. Slocum's own method of reasoning we have:

TiO_2 takes up 0.66 oxygen.

Ti..............	48	$\frac{32}{48}$ equals 0.66.
O_2 (2×16)	32	

V_2O_5 takes up 0.784 oxygen.

V_2 (2×51)	102	$\frac{80}{102}$ equals 0.784.
O_5 (5×16)	80	

Then the comparison stands as follows:

1½ titanium takes up 1.00 oxygen.
1½ vanadium takes up 1.176 oxygen.

In other words, vanadium is 17.6 per cent. more powerful than titanium, by Mr. Slocum's method of calculation.

MR. C. V. SLOCUM.—Mr. Norris has made a clever showing for a good alloy. I have made an equally good or even better one for titanium. We need not rest on mere figures, since doctors have apparently disagreed. I would name some higher authorities than either of us:

Prof. Henry M. Howe, who has said within a year: "Titanium has a stronger affinity for oxygen than have the other well-known deoxidizers . . . it probably gives the slag such a consistency that it separates more completely from the molten iron."

Prof. Bradley Stoughton says: "The presence of titanium oxide lowers the melting point of slags occluded in iron and steel and it imparts thereto sufficient fluidity to account for their elimination."

Prof. H. Le Chatelier says: "The treatment of all steels with ferro-titanium for the purpose of purifying the metal is strongly recommended." The statements of Moissan, Whoeler and others agree with those I have already given, hence it seems unnecessary to take up time in quoting them since it would be simply a case of adding truth to truth.

PYROMETRY.

Address by S. H. Stupakoff, Pittsburgh, Pa.

When I met your Secretary about three weeks ago in this city, I asked him to let me have the advance copies of the papers on Pyrometry that would be announced in the provisional program of the convention. I was surprised to learn that so far he had none on this subject, but that he had counted upon getting one from me. I see now that I am put down for a paper which I have not prepared, though I have written something for the occasion along the same lines. If acceptable and found worth publishing, you will no doubt receive a copy of it in due time when the other papers that are here read have been printed.

I expected to take part in the discussion but had no intention of tiring you with the reading of a long paper which could not be otherwise than abstract. I fully appreciate that you, or most of you, as American born, must find it far easier to read an essay written in the English language, and in that manner be better able to digest it, than by following me, reading. Though I have been among you for more than twenty-five years, I am aware that my pronunciation still carries with it its foreign accent, that it may never lose. Moreover, I am sure that you want to take a breath of fresh air while you are attending the convention, and every chance should be given you to enjoy your outing. I do not wish to see you suffer under this sweltering heat, and in putting my manuscript aside, I would request that you allow me merely a few minutes to say some words on my subject as they may come to me.

The program announces that I was to bring you a paper on "Recent Developments in Pyrometry"; though I am sorry to say that at present I have nothing that could pass under this title, I promise that, if you will wait until the next opportunity, you shall have it. As a substitute therefor, I am placing herewith into the hands of your learned Secretary some remarks and recommendations "On the Selection and Use of Pyrometers."

It appears that this is a subject which should be of some

interest to all foundrymen; because, in the first place it is difficult to select the most suitable high temperature measuring instrument to fit specific conditions, especially in cases like yours when dealing with molten metals; and, secondly, the largest number of failures in making successful use of pyrometers are undoubtedly due to their wrong application.

It is really surprising how few will consider that all these apparatuses need judicious handling and a liberal amount of care to give the desired satisfaction. Some may look at pyrometers merely as a new-fangled idea, as a fad; others may object to applying new methods, while still others, perhaps the majority, expect that such instruments should withstand more than what they were designed for. Let it be remembered that their scope of usefulness is not exempted from the law of limitation.

You will readily admit that it is unreasonable to expect unlimited good service from an ordinary metallic implement, be it an iron rod or a pair of tongs, under prolonged exposure to molten masses of metal, to a blacksmith fire, or to any type of heating furnace. Why is it then, that more should be expected from a pyrometer? Many of the cheaper grades of pyrometers consist in part of iron or copper, or of other base metals or their alloys, and there is not a single one among the lot that could withstand continuous exposures to temperatures greatly exceeding red heat, without rapidly deteriorating and losing its electrical qualities. This is the principal reason why base metals are unfit to be used for the measurement of high temperatures, and we are therefore compelled to employ rare metals possessing a high melting point. And even these are subject to the same trouble though to a considerably less extent—if they should not be effectively safeguarded to prevent their gradual destruction. This would infer that it is of paramount importance to select a reliably effective protection for the vital portions of pyrometers, which are directly exposed to high temperatures.

In looking over the field of substances which may be of service for this purpose we quite naturally stop at the group of refractory materials. Among these we find a number which will withstand the highest ranges without appreciably deteriorating. Their components are mostly alumina, magnesia and silica. Depending upon different proportions of such materials in a

mixture and subsequently burning them under high heat we obtain a large variety of compounds among which are the various fire clays and porcelains which have very high fire resisting qualities.

Another substance which in this respect fulfils our requirements to a remarkable degree is fused silica. No doubt, many of you have used it in one form or another. It is made of pure quartz crystals by the aid of an electric arc. Its manufacture has been brought to perfection only within recent years. The production of pure quartz glass articles evidently found an incentive through the necessity of providing a suitable protection for the costly platinum wires which compose the vital parts of the majority of high class pyrometers. Since then other useful applications for articles made from this material have readily suggested themselves, and it is now quite frequently used whenever high temperatures and the actions of acids, either cold or hot, or in the gaseous state have to be contended with.

Quartz glass articles for the protection of pyrometers are made in tubular shape with closed end, and in this form they render excellent service. They will readily withstand a temperature of 2,200 degrees F. without being in the least affected. At a higher temperature they commence to yield, and thus may bend if kept in a horizontal position. However, they do not become sufficiently soft to collapse until they reach about 2,800 degrees F. and therefore they may be applied quite frequently until this temperature is reached, if used in a vertical position. They are not affected in an oxidizing atmosphere, whereas a reducing atmosphere causes gradual devitrification.

One of the greatest advantages they have over other refractory materials is, that they will withstand sudden cooling without danger of cracking. In fact, they may be heated red hot and plunged in cold water without being affected. This seems to be quite strange, if we should judge solely from their appearance, which is very much like that of our ordinary glassware. The cause of this property lies in the exceptionally low coefficient of expansion of silica, which means that this substance neither expands nor contracts materially between wide ranges of temperature.

To illustrate the difference between high and low coefficient

of expansion, I will but mention a single drastic case that has come under my own observation in connection with silica. It happened that one of these tubes was injudiciously applied and allowed to become coated on one side only with a layer of oxide of iron. Upon cooling, the iron coating contracted to such an extent that it pulled out a portion of the side of the silica tube, and it could be plainly seen by the axial curvature of the broken portion, that the latter material had offered a considerable resistance to yielding to the strong pulling action of the iron.

Though all the qualities mentioned point favorably to the use of fused silica protection tubes for pyrometers, it should be borne in mind that they have the same unavoidable disadvantage of brittleness in common with all other refractory materials. When struck with a hard substance they will break as easily as glass. Nevertheless, it would appear that nothing—representing the same fire-resisting qualities—equals quartz glass as to its property for withstanding sudden changes of temperature without sustaining serious damage or entire destruction. This qualifies quartz tubes especially for use in connection with portable pyrometers which are temporarily but suddenly exposed to variously high temperatures of furnaces, and which likewise are as quickly withdrawn therefrom to cool down to the temperature of the atmosphere.

A better protective covering for the expensive platinum portions of pyrometers is unquestionably the high grade Berlin porcelain, and the best of all known at the present date is undoubtedly Marquardt mass, which is solely made by the Royal Porcelain Factory at Berlin, Germany. Both substances are of a highly refractory nature, and both, when covered with a hard silica glaze, become impermeable to gases, remaining so even at considerably high temperatures. Both have a very high melting point, especially the Marquardt mass, of which it is claimed that it will withstand 3,600 degrees F., a temperature which is not ordinarily met with, excepting in arc furnaces, in oxyhydrogen and oxyacetylene flames and in the thermit process. The point at which they begin to soften and at which they will commence to bend, however, lies but little above that of other refractory materials. I have frequently observed that they will yield in this respect at about 2,250 degrees F., if kept in any other but the vertical position.

One of their principal disadvantages—besides brittleness, in which they are not superior to other substances of the kind—is, that they are extremely sensitive to sudden changes of temperature. They will easily crack when brought from heat into cold or vice versa. It is therefore recommended that they be heated up gradually with the furnace and be allowed to cool down with it. I have found, however, that when they are provided with suitable outer covering of fire clay, plumbago, alundum or anything else of the same nature, which need not be impervious to the transition of the gases of combustion, they will withstand considerable abuse in that direction. The user should be also cautioned to keep such substances out of touch with fluxing agents, as these will invariably destroy them at high temperatures. Neither Berlin porcelain nor Marquardt mass tubes can be recommended for use in connection with portable pyrometers, unless they are handled by very careful operators who will take the utmost precautions to prevent their cracking.

Occasionally it may be perfectly satisfactory to use the cheaper grades of fire clay for the purpose of insulating the two individual wires of a thermocouple.

Domestic porcelains, as a rule, are rarely suitable for pyrometer protection tubes which are exposed to temperatures exceeding 1,800 degrees F. And even considerably before reaching this point they show a perceptible falling off of impermeability to the gases of combustion. This, no doubt, limits their use, but it does not condemn them altogether. Many metallurgical processes are conducted below 1,800 degrees F., such as the annealing, hardening and carbonizing of iron and steel, the annealing of glass, galvanizing, tinning, lead coating and innumerable other operations; and in all these it is therefore quite admissible to make use of domestic porcelains to good advantage. They are superior to fire clays on account of their greater mechanical strength and greater density, and to Marquardt mass and fused quartz—within their region of applicability—because they are less expensive. They are especially serviceable as inner tubes for insulating the individual wires of thermocouples, when provided with double bores. It is in my opinion useless to attempt applying any ordinary grade porcelains at temperatures exceeding 1,000 degrees C. (or about 1,800 degrees F.), regardless of what is being claimed for it.

I recollect several instances when representatives of porcelain manufacturers came to me recommending tubes of their own make as being superior to those made of Marquardt mass. Though it is never claimed that the latter is a true porcelain, they invariably attacked its qualities on account of the dull amorphous appearance on fracture. I could not convince them that the glossy or vitreous structure of their samples meant nothing until I tested some of their material in their presence in one of my electric furnaces. Invariably it broke down in the neighborhood of from 1,800 degrees to 2,000 degrees F. It sintered together to a porous and blistered mass that had a spongy appearance somewhat like pumice or cinders. There was certainly nothing left that might have likened it to any grade of porcelain, even of a vastly inferior quality than what it was recommended to be. It was simply a demonstration of "The proof of the pudding is the eating." There were no further arguments, as it was evident that the material offered could not be used for pyrometer purposes, excepting within comparatively low regions of temperature. After many trials of this kind I have given up the attempt to use domestic porcelains above 1,800 degrees F. Notwithstanding this, I shall be glad to test at any time other materials of this or similar description in the hope of finding something that may be to the advantage of my friends and customers whose patience and confidence have been one of the greatest incentives for me of continuing in my chosen path.

Now, in applying pyrometers to molten masses of metal we meet with considerably greater difficulties, because it is essential that direct contact between the thermocouples and the molten metals must be avoided to prevent destruction. Platinum or its compounds alloy easily at read heat with other metals in the molten state; and though the melting point of platinum, according to the most recent investigations lies at about 3,120 degrees F., it will melt down at red heat in molten tin—which melts at 418 degrees F.—like a tallow candle in a bowl of hot water.

It should be further considered that platinum possesses in a high degree the property to absorb at red heat gases and metallic vapors, which in this state form therewith metallic compounds. They are invariably detrimental to the electrical qualities of the metal. Thus, platinum carbides, formed in this manner—which

is of the most common occurrence—may cause the entire loss of the thermo-electric qualities of a thermocouple.

From all this it would appear that one of the most important considerations in practical pyrometry is to keep the active portions of thermocouples away from all destructive and deteriorating influences. The careful selections of the most suitable materials for their protection and judicious handling will therefore be the measure of success or failure in the application of high temperature pyrometers in the industries.

There are many prospective users of pyrometers who think that after they have decided upon the purchase of such an instrument it should be entirely sufficient to inquire of a dealer or manufacturer of such apparatus as to price, and best terms of delivery. They invariably lose sight of the fact that it is quite impossible to make an instrument of the kind which can be used universally for all purposes. There is no such a thing as a universal pyrometer, and there never will be. To give results, and the desired satisfaction, each individual case should be carefully considered by itself, and each instrument should be especially adapted for the specific purpose that it is intended for. If it should be found afterwards that the same form or type of pyrometer can be applied with equally good results for similar heat measurements, there will be the much less reason for fault finding. All the conditions being known, there are, nevertheless, quite frequently opportunities when pyrometers of suitable design and construction may be devised which may answer exceptionally well for general tests and inspection work in actual practice. However, as a rule, the specific purpose for which a pyrometer is to be used should be mentioned upon inquiry or when ordering same, and a conscientious dealer or manufacturer of these instruments will always inquire of his prospective purchaser to that effect before filling an order.

Ever since I have taken up the study of pyrometry—and I may say truthfully it has become my hobby—I have looked into the requirements on these lines of a large number of different manufacturing processes. Within that time, I am sure, I have made no less than fifty or sixty different forms of pyrometers, each of which was specially adapted for its specific purpose. If I have rarely failed to make a success of the practical application

of these instruments in factories and workshops, and if I succeeded in ninety-nine cases out of a hundred to satisfy my friends and patrons, it may be principally ascribed to carefully weighing the facts that had to be contended with, to discriminating in selecting and devising the most suitable apparatus for the purpose and to giving liberal advice on their use and full instructions for their installation.

Even if it should not have been distinctly mentioned it must have been understood that the gist of the comments so far made referred to pyrometers which are directly exposed to the heat that is to be measured. And this therefore covers the groups of thermo-electric and resistance pyrometers. The active portions of both types, when intended for the measurement of high temperatures, consist mostly of platinum or alloys made from the platinum group of metals. This means the employment of very expensive materials. Hence, if it were for this reason alone, it is always advisable to make use of the most effective means to prevent their untimely destruction. But as the fact has been established that at high temperatures the deteriorating qualities of the surrounding medium may quite frequently seriously affect and sometimes even entirely destroy some of their electrical qualities, it is doubly important to apply the best possible safeguards for their preservation.

While the group of thermo-electric pyrometers unquestionably covers the widest range of temperatures of the two types, extending as it does, from the absolute zero to more than 3,000 degrees F., we have in the resistance pyrometer an excellent instrument that will render excellent service up to about 1,500 degrees F. However, these two groups of pyrometers, which may be and have been successfully used within their specific limits for the measurement of high temperatures, are by no means the only ones that are to be had for the purpose. There are quite a selection of others in the market. It would take too long to give a description of all but with your permission I will mention a few of them, which have found quite an extensive use.

One of the oldest, which is undoubtedly known to many of my hearers, is the Siemens water pyrometer. It consists of a specially constructed vessel, protected effectively against heat losses, which contains a definite quantity of water and therein a

very delicate thermometer with fine divisions, representing small fractions of a degree of our temperature scale, and further of an active accessory consisting of a small iron, copper or platinum cylinder. The latter is exposed to the temperature which is to be ascertained. After heating, it is quickly withdrawn, plunged into the vessel with water and then the increase in temperature of the latter measured. Now, since we know the specific heat of either one of the materials of which our cylinders consist, it is an easy matter to calculate their initial temperature—which is of course the same as that of the furnace to which it had been exposed.

The accuracy of these measurements depends as much upon close observation of the weight of water and metal cylinder used, as upon that of the rise of temperature of the water. And consequently it will be necessary to carefully weigh the cylinder after each exposure on account of loss in weight through scaling. It may be needless to say that the use of platinum cylinders for this purpose is practically excluded on account of its prohibitive high price, which is at the present time about $48.00 per ounce.

On the other hand, the use of iron or copper cylinders is unavoidably linked to loss in weight, and resultant therefrom to tiresome calculations. For these reasons I tried to find another and more suitable substance to take their place. Having explained to you at length some of the remarkably good properties of silica under the most trying changes of heat conditions, it may not surprise you to hear that I selected this material for my experiments along these lines, and that the results obtained therewith were very gratifying.

Originally I intended to use artificially fused quartz—principally for economical reasons—but not being able to secure just what I wanted I was compelled to employ the natural product. The cylinders which I had cut in this manner from pure quartz crystals were reasonable in price; they could be exposed to considerable higher temperatures than either iron or copper; they were not appreciably affected when heated in an oxidizing atmosphere, and when almost white hot they could be plunged into cold water without damage. I admit that I am not quite through with my experiments on these lines, but notwithstanding this I have good reasons to believe that it will take but little more effort on my part to prove that we have in quartz an excellent substance for use in connection with water pyrometers.

Another simple form of pyrometer, or more properly speaking "pyroscope" that has been, and is even now used quite extensively—mostly in the ceramic industries—are the Saeger cones. They are little pyramids approximately two inches in height, which when standing on their base, incline slightly to one side. In practice they are placed on a slab of fire brick and thus exposed directly to the heat of a furnace of which the intensity is to be ascertained. Their behavior is observed through a peep hole from the outside, and they are watched until they commence to lean over or collapse. This indicates that that certain temperature has been reached for which they were intended. They are graded according to their softening or melting points and are known by consecutive numbers. Each number, of which there are about sixty, represents a definite range of temperature which, however, is only approximately so and not claimed to be absolutely correct. It must be plain to you that after these cones have been in use once they are done for, and that they must be replaced by others after a single application. But then, they are comparatively cheap, and this feature alone does not seem to offer sufficient reason for objection to their use. Their application may be entirely admissible in some manufacturing processes in connection with which it is sufficient to know that a certain maximum temperature has been reached, whereafter the heating has to be stopped. We meet with such conditions in the manufacture of porcelain, terra cotta, brick pottery and allied industries. But their use is waning even in these branches, and they are gradually making place for more modern devices which give either continuous indications or furnish permanent records. Wiborgh's thermophones, which give oral indications and sentinel paste, are slight variations from the original Saeger cone, and they must be counted into the same class.

While we have good reasons to believe that Saeger cones will remain representatives of the simplest, crudest forms of high temperature measuring devices, it would appear that the same train of reasoning would lead us to conclude that electric resistance pyrometers will continue to occupy the highest rank at the other extreme.

They are capable of giving information of exceedingly high accuracy. With their aid it is possible to obtain within small

fractions of a single degree all temperatures that lie within their range, *i.e.*, from the absolute zero (—461 degrees F.) to about 1,500 degrees F. They should not be exposed above 1,500 degrees F., as at this temperature they commence to undergo a permanent change, which materially affects their resistance. This fact has been but recently established, though resistance pyrometers have been in extensive use for many years. The cause is probably due to volatilization of minute portions of the metal. This, at least, would account for the fact that the electromotive force of platinum, platinum-rhodium couples (not Pt., Pt. Ir.) remains practically constant, which is not so with its resistance.

Up to within a recent date there existed exclusively platinum resistance pyrometers, lately, however, there are others on the market made of a nickel alloy. They are only recommended for use below the lower transition point of nickel, which brings them well within the range of our commercial thermometers.

Optical pyrometers are applicable for the measurement of temperatures from red heat up to the highest attainable points. They are highly recommended by many scientists who have found them to be excellent accessories in their laboratory research work. Though these instruments have been introduced to some extent in factories, it is my personal opinion that it remains an open question whether they will ever gain here a solid foothold. Their reliability is absolutely dependent upon the personal factor of the user. It depends as well upon the condition of the eye, the state of health and the temperament of the operator as upon the condition of the surroundings of the object under observation. All these may be gauged, observed and adjusted to a nicety in a scientific laboratory, but as far as my experience goes, it is well nigh impossible to attain these even approximately so in a workshop. It is well known that, even under the most favorable conditions, two men will rarely obtain the same results by using an optical pyrometer in a factory. I can say this truthfully from personal experience. Hence, it would seem at least advisable that the personal element be eliminated, whenever physical quantities of this nature are to be determined within reasonable degrees of accuracy.

It is entirely different if the same instrument is used by a physicist in his laboratory. His vocation is to overcome obstacles,

and he is a dire failure unless he sticks to a problem until he obtains agreeing results. He knows that there are no flaws in the laws of relationship between heat and light, and that these two quantities must be made to agree before he dares to give up. He uses his instruments day after day, does his own calibrating, and carefully determines his personal equation, which is entered as correcting factor in all his calculations. Such painstaking practice cannot fail to overcome the greatest difficulties and to exclude possible grave errors, and our man is content and highly gratified if he achieves his object in the end—regardless of the time that it took him to get there.

But that would never do in ordinary shop practice. The practical worker has neither the time nor the inclination to make the minute adjustments and perform the cumbersome calculations which the use of such instruments require, nor has he that much patience with refinements of construction and delicacy of manipulation, and a trained specialist is rarely at hand. The nearer the methods used approach the rough and ready, and the simpler his working appliances are, the more they will appeal to him. He would swear by us if we could give him a pyrometer constructed after the principle of the sledge or the crowbar or the battering ram. It is really too bad that we are not sufficiently advanced in this science to meet his expectations and his wants in this direction.

To be of any value from the viewpoint of the manager or superintendent of a factory, it is of paramount importance that measurements made by different observers must strictly coincide; they must represent reasonably accurate results and it must be possible to obtain the required data on short notice,—often within a rather short space of time. The tapping of a cupola and the rolling of steel and iron may serve as fitting examples.

These are some of my reasons for believing that optical pyrometers will remain distinctly laboratory instruments, and that as such they may continue to render as excellent services as heretofore, whereas but little room will be found for them in the shop.

All this is true, notwithstanding the fact that ordinarily we most implicitly trust our unprotected sight as to the degree of temperature of all bodies above red heat.

In contradiction to the foregoing it may be argued that the principal advantages possessed by optical pyrometers are that they are suitable for the determination of the highest possible temperatures and that they are never brought in immediate contact with the object under observation. Thus they are not subject to destruction on exposure to high heat.

This is quite so, and these are certainly points in their favor when thrown into the balance against the properties of thermo-electric resistance and other types of high temperature measuring instruments. But even then we are not solely dependent upon the optical method of measurement, from which—at least so far—it has not been possible to eliminate the personal element.

Radiation pyrometers cover the same scope, they are not directly exposed, but used at a distance from the source of heat of which the temperature is to be determined; they are not dependent upon personal equation and they are distinctly mechanical contrivances which can be constructed either as indicating or recording instruments. It would seem that the latter feature alone, which makes them independent from the operator, should recommend them as preferable to optical pyrometers for use in practice.

We have at the present time two types of radiation pyrometers, one constructed after the thermo-electric and the second one according to the expansion principle. The former is the one most commonly in use. The active—which is at the same time the sensitive—portion of these instruments is located within a telescopic tube and adjusted to the focus of a concave or conical mirror. The vocation of the mirrors is to collect a definite amount of heat rays and to concentrate these on the active portion of the instrument when the telescope is properly focused on the object.

The thermo-electric type of these instruments contains a very delicate and extremely sensitive thermocouple of high electromotive force, and the expansion type a minute spiral of compound metallic ribbon—not much larger than a pin head. Either one of these is acted upon by the concentrated bundle of heat rays. The consequence is that the thermocouple generates an electric current, which is made to deflect the needle of a sensitive indicating or recording galvanometer, while in the

expansion type one end of the spiral connects to a pointer and in expanding or contracting makes it move over a scale in either one or the other direction.

A matter of the greatest importance, which must not be lost sight of with reference to radiation pyrometers, is that the construction and calibration of all instruments belonging to this group is based upon the Stefan-Boltzmann law of black body temperatures which expresses the relation between the temperature of a body and the amount of radiant energy which it emits.

It should be understood that a black body absorbs all the radiation which falls on it, and reflects none. Imagine a red hot hollow sphere with a block of a solid non-reflecting substance, such as carbon or a metal coated with a black layer of oxide suspended in the center. Such a block will absorb all the heat that falls on it from the walls of its enclosure, and the radiant heat omitted, or the total energy radiated to the surroundings will be a true measure of its absolute temperature, inasmuch as it is proportional to the fourth power of the latter. A small opening in the sphere, which may have been provided for observation of the interior, does not materially affect the result.

The nearest approach to perfectly black bodies are enclosed furnaces, muffles, combustion and heating chambers and similar contrivances that we meet with in daily practice. They may be safely considered as true representatives of effectively black bodies, and therefore we should obtain trustworthy results from a radiation pyrometer that has been properly applied to the same.

However, we have different conditions to contend with when applying these instruments to heated objects in the open. Hot masses in the open air sustain a considerable loss of heat by convection, reflection and radiation into space, and only a part of the energy emitted is represented by radiant heat, which is the only form collected by the mirror of radiation pyrometers. And consequently the readings of the instruments will be lower than the true temperature when the object sighted upon is not a true or an effectively true black body. The reading thus obtained, without correction is called the black body temperature of the test object. The true temperature may be deduced therefrom by applying to the resulting indications reliable correction factors,

which differ with the materials, as well as with the conditions under which the objects are being observed.

Attempts have been made by different investigators to establish reliable correction factors for the loss of radiant energy of various substances in the open atmosphere in order to determine the true from the black body temperature of a substance. However, it would appear that the results obtained should be taken with a good grain of salt. They are certainly considerably at variance. This may be due to the fact that the conditions under which such observations have been made may not have been identical. It cannot be questioned that it must be extremely difficult to obtain absolute agreement on matters of this kind, as the results must necessarily depend upon almost unavoidably changing conditions. I believe, nevertheless, that the magnitude of such errors of observation may be considerably reduced, and possibly be brought within practical limits by applying suitable means which have the tendency to eliminate fluctuations. I have done some work in this direction, especially in connection with molten masses of metals and slags, and I believe that the results obtained should at least warrant a continuation of my researches on the same or similar lines. The method employed by me seems to be ridiculously simple, as it consists merely in interposing a float of a refractory substance between the molten mass and the telescope of the pyrometer, upon which the latter is focused. The float is preferably selected as thin as possible, and it may be provided with a rim to prevent the liquid mass from running over its surface. It is heated of course quite rapidly to practically the same temperature as the fluid mass itself through its immediate contact with the same, and it is an effective means not only for eliminating the excessive aberrations, mostly caused by difference in reflecting power, but at the same time for reducing the remaining error—which is easily established—to a single uniform constant for all molten substances.

This method is likely to be rejected as unsuitable for laboratory work, where only small quantities of materials can be handled; but after all, we are best served if it will give the desired results in our works where the quality of tons of molten masses are dependent upon proper heat treatment.

In conclusion permit me to say that the present discussion covers but a small portion of the extensive field of practical pyrometery. Much had to be left unsaid, in order to bring the subject matter within our limited compass of time. And yet, what has been said may be sufficient to convince you that the advancement of this modern science has kept pace with our progressive times.

I extend to all present foundrymen, metallurgical engineers and chemists a cordial invitation to visit my laboratories, where I have a very good collection of temperature measuring devices for all ranges. I shall be glad to have you examine these instruments, and with the facilities that I have there at my disposal, it would give me pleasure to show any of them in operation, in which you may be particularily interested.

DISCUSSION ON MR. NORRIS' PAPER ON VANADIUM IN IRON AND STEEL CASTINGS.

Mr. Shed.—I would like to ask Mr. Norris if in addition to adding vanadium alloy in cylinders where it is necessary to pour a large quantity of iron when the metal itself has been properly treated, what is the gain in adding vanadium?

Mr. Norris.—The advantage in adding vanadium in large cast iron cylinders is just the same, and there is no difficulty in adding vanadium. That has been done regularly in the American Locomotive Works foundries. It has been done on five hundred pair of cylinders and there is no difficulty in holding the iron hot enough; you can hold the iron hot for three-quarters of an hour if desired.

Mr. Shed.—Vanadium will not make up successfully. When we made some locomotive cylinders using vanadium we were extremely careful to put in a large amount of ferro-manganese, and it looks to me as if the good work was being done by the ferro-manganese and a very little done by the vanadium; and when we made the test we found the tensile strength of the cylinder about 27,000 pounds for the common iron, and about 27,800 on the vanadium. The amount of increase in itself is so small that it is not worth considering. From making a good many tests we found by making cylinders out of common stock, that is, out of ferro-manganese, we were as well off as when we used vanadium, which cost a great deal more.

Mr. Norris.—What cylinders do you refer to, please?

Mr. Shed.—The cylinders in question are running on French railroads now, and I wouldn't be able to say how they are doing because we have had no opportunity for observation or tests.

Mr. Norris.—I am not advocating vanadium for increased strength in cylinder work, but for the quality of the cylinder. The records which have been carefully compiled, show that the cylinders stand two to three times the mileage of cylinders not treated with vanadium without reboring. It is immaterial whether they are stronger or not as strong as with ferro-

manganese. The test to my mind, as I have stated in my paper, is their wearing quality.

Mr. Shed.—You are after a certain low silicon. You do not attempt anything more than we do, do you, to make a cylinder out of higher silicon? You don't want to raise that silicon to 2 and 2¼,—you are keeping that down. Now, you are getting good results from low silicon, but not from ferro-vanadium?

Mr. Norris.—Some American roads on which records have been kept have found vanadium cylinders to work very satisfactorily. On the New York Central Lines, for instance, they have some cylinders that have been running for about three years.

Mr. Shed.—I would like to see a comparison at the end between the vanadium and the ferro-manganese cylinders.

Mr. Norris.—I have received reports at intervals on these cylinders and they show a wearing average of over twice that of the regular cylinders in which ferro-manganese was used.

Mr. Shed.—You couldn't see in the chips or the borings—I mean the general borings—anything different from those of the cylinders.

Mr. Norris.—May I ask what foundry you are referring to?

Mr. Shed.—The Buffalo Foundry and Machine Company.

Mr. Norris.—It might interest you to know that the Santa Fe Railroad consider the best cylinders they have are some which are being made out in Kansas, which contain 2 per cent. and upward of silicon. You know most of the steam-hammer cylinders will carry 2.50 per cent., or in that neighborhood, of silicon.

Mr. Shed.—You do not consider that those cylinders wear as well as the hammer cylinders.

Mr. Norris.—They are supposed to wear better.

Mr. Shed.—2.50 per cent. silicon hammer cylinders machine easily. And for no other reason under heaven we make them so that we can turn them out of the shop easily. The idea that cylinders with 2.50 per cent. wear as well as one with 1.25 per cent. is absurd.

Mr. Putnam.—Mr. President, I would like to say that simultaneously with the introduction of vanadium into foundry practice, especially in the steel line, has come more detailed attention to heat treatment, and it seems to me that some of the

thunder of the heat treatment has been stolen by the vanadium people, although there is no doubt but what vanadium in some instances works good results. This is especially so where people who have been using vanadium steel, particularly for automobile work, find they can get good results which will answer all requirements simply by giving the steel a more refined heat treatment.

Of course, as the speaker has said, the good effects of vanadium come from the fact that it is a scavenger.

Mr. Norris.—I differ with you there; I didn't say that.

Mr. Putnam.—I thought you did,—I must have misunderstood you.

Mr. Norris.—I didn't say that.

Mr. Putnam.—That claim has been made for vanadium, and it seems to me from the experience I have had in connection with the use of vanadium, that it does act very rapidly in removing the last traces of oxide.

Mr. Norris.—Have you made any chemical analyses to demonstrate that?

Mr. Putnam.—Yes, sir.

Mr. Norris.—That it removed all the oxides?

Mr. Putnam.—Well, I couldn't say as to that exactly—that it removed all the oxides, but it did remove a certain percentage of them.

Mr. Norris.—I find in making steel, whether for castings or forgings, that I want to get all the vanadium possible into the steel, and the more I get into the steel the better. If you add .25 per cent. and could get in all of the .25 per cent. added, the results will be better than if you got in only .20 per cent. The treatment of vanadium steel castings is practically identical with that of all steel castings.

A Member.—I would like to ask Mr. Norris if it is not a difficult matter to obtain a gray iron casting that will go 30,000 to 35,000 pounds tensile strength.

Mr. Norris.—Certainly not.

A Member.—But have you been able to ascertain whether the addition of the vanadium is going to increase the tensile strength of that iron?

Mr. Norris.—Yes, it will; I have made iron castings that will go say 4,000 pounds transverse and 40,000 tensile. I get a

little increase in that by the addition of vanadium, but it is not the increased strength I am advocating, as I said before, so much as it is the superior wearing qualities for certain classes of work, and that has been amply demonstrated.

I would not personally pay $5 a pound for vanadium if I wanted to increase the strength of iron. If I was making iron with 17,000 pounds tensile strength I wouldn't put in vanadium to bring it up to a greater strength,—I would change my mixture.

One reason I took the stand I did in my paper was to dispel certain ideas that vanadium was a sort of cure-all and would do all sorts of stunts, and I wanted to indicate that for certain purposes it would not be worth while to spend money for it because you can get those results in some other manner. It is only where the vanadium will give certain qualities to the iron that you cannot obtain from other metals that I advocate its use.

Dr. Moldenke.—I think, gentlemen, that I made the first experiments on vanadium in cast iron. I found that vanadium does act as a scavenger of the oxides present, but it is an awfully expensive one. It would be throwing money away to take oxygen out of iron by means of vanadium, but I found that after the iron was deoxidized by some of the vanadium added some still remained, and this gave excellent effects.

The only place where vanadium did specially good work in the way of increasing tensile strength was in white cast iron. I found it was increased to three times by vanadium. Whereas, in gray iron I found no special increase in the strength. The wearing qualities I do not know anything about. But I was certainly astonished to see white iron test bars brought up from 1,000 pounds transverse strength in the bar to 3,300 pounds.

Mr. Norris.—I see Mr. Gibney here. He has had a great deal of experience in the manufacture of vanadium iron.

Mr. Gibney.—I have had some experience in vanadium iron, and I do not know any case in which the test made did not show a considerable increase both as to transverse strength and the tensile. We have made in the last three years possibly fifty or one hundred trials of it, and we have always gotten these results. As to the wearing qualities, that remains to be seen, of course, but in some cases we had very favorable reports from users of our vanadium iron castings.

Mr. Shed.—There seems to be a great change of base on the

part of the exploiters of vanadium. Last year Mr. Kent Smith, who seemed to be the greatest authority, made a point that it was a scavenger, and now this year we hear that put to one side as an immaterial point. It is rather strange that the same concern should have such a change of base in one and a half years.

MR. NORRIS.—That change is more apparent than real.

Mr. Kent Smith laid considerable stress on the scavenging properties of vanadium, but never advocated this as its principal quality. The experience of the last few years has shown that the value of vanadium as a scavenger was of minor importance, and that on account of its cost should not be considered in this connection.

The addition of vanadium is generally accomplished now with only a slight loss.

The action of vanadium on iron and steel was described by Mr. Kent Smith as taking place in three ways, one of which was scavenging. This was the most simple action, though the least important, and appealed to many. Some manufacturers even used it as a means of palming off on their customers material to which they never had added vanadium.

MR. NORRIS.—(Communication)

I have gone through my files and find that the American Vanadium Company furnished the Buffalo Foundry and Machine Company with some vanadium in the early part of 1908 for the purpose of making a vanadium cast iron cylinder for the American Locomotive Works. This cylinder I find went to the New York Central Lines, and not to France. For comparison with it a cylinder without vanadium was also made by the Buffalo Foundry and Machine Company. These cylinders and others also were given a service test, and as a result the New York Central Lines have since ordered vanadium cast iron cylinders for their new locomotives, some 500 engines in all. The conclusion is obvious.

PROCEEDINGS OF THE PITTSBURGH CONVENTION.

May 23–26, 1911.

First Session.—Tuesday, May 23, 10 A. M.

The Convention was called to order by the President, Major Jos. T. Speer, at 10 A. M. Tuesday, May 23, 1911.

Major Speer requested Past President Joseph S. Seaman, Honorary Member, and one of the organizers of the Association, to address a few words of welcome to his many friends, the audience present.

Past President Joseph S. Seaman:—I have not come here to say much to you, but to bid you heartily welcome. I speak for the Pittsburgh Foundrymen's Association as well as for myself. We have done all we could and made preparations to entertain you during the few days you will be with us. We do not expect to take you around and show you everything we have in Pittsburgh—we are a little too large for that—but we will do the best we can to entertain the ladies and gentlemen attending this convention and make their stay with us a pleasant one.

If anyone wishes to visit any of the industrial works around and in our city and will let this be known at the Information Bureau or to some of the Committee members, we will endeavor to have you see the plants in question.

We bid you all welcome and we hope you will be happy all the time you are with us.

President Speer:—We hoped, ladies and gentlemen, to have had the Mayor of our city here to address you this morning, but he has been called away; he has, however, sent to you one of his representatives to speak in his behalf and for him to welcome you to this city. I have the pleasure of introducing to you Harold M. Irons, Esq., who will speak for the Mayor.

ADDRESS OF MR. IRONS.

Ladies and Gentlemen:—It affords me great pleasure to welcome to our city the members of the American Foundrymen's Association and allied associations, and in the name of our Mayor, the Honorable William A. Magee, I gather thousands of cordial greetings from the hearts of the people and compress them into a bombshell of hospitality, toss it from my lips and it explodes above this vast assemblage, leaving a forget-me-not for each and every one of you. We welcome the ladies to our city, but it goes without saying that the rays of sunshine can come in whenever and wherever they please.

When I look over this assemblage, I feel that we could very appropriately begin these proceedings by all joining in singing "The Anvil Chorus." But you gentlemen are not in the condition that Mike and Pat were in. Mike and Pat died and went to the great beyond. Mike went to Heaven and Pat went to the other place. And, finally, Mike looked down from his abode above and he saw Pat down below, shoveling coal, and he said to Pat:

"How are you getting along down there?"

Pat replied: "I am getting along fine."

"Do you have to work hard?"

"No, we don't have to work hard. We only work two hours a day. It is a pretty good place. We have twelve shifts. And Mike, how are you getting along?"

"Fairly well; fairly well, thank you."

"And are you doing any work?"

"I am sweeping down the golden stairs."

"Do you have to work hard?"

"I have to work about twenty hours a day. We are short of men up here."

Now, gentlemen, you don't seem to be short of men in this convention, and I do not know what your other conventions have been, but I do believe that this convention will be a great success.

Due to pressing engagements, Mayor Magee cannot be with you to-day. It is your misfortune in not being able to listen to him in an address of welcome, as there are few men in the country better versed than he in municipal affairs. He is a young man—energetic and tireless in his efforts to better the

conditions of the people of this community and to inaugurate true and permanent reforms. He has accomplished much during the short tenure of his office, and when his ideas have been transformed into realities the people will then accord him the recognition and praise he deserves. Strangers from other cities have doubtless heard much concerning Pittsburgh and from what they have heard recently they no doubt consider that Pittsburgh is the home of the humbug, but from some of the slanderous articles we have been reading lately, I have no doubt that you feel that even Satan must feel dreadfully antiquated and lonely among so many modern improvements. Let me assure you that such is not the case—in business and in morals we are the equal of any city of our size on the face of the globe. These facts will be made apparent to you during your sojourn among us and when you depart you will carry with you only the most favorable recollections.

Your Association is closely related to Pittsburgh. It is woven into the warp and woof of our city. Pittsburgh has been the home of the foundrymen. In modern manufacturing Coal is king and Iron is his scepter. By reason of the natural water courses and the vast coal fields of western Pennsylvania, Pittsburgh has grown into a great iron and steel industrial center. Some of the foundries of this locality are perhaps among the best in the world. This is a great city—where we make iron and "steal" for a living.

You gentlemen have associated yourselves together for the improvement of the art of founding, and your art is in its infancy. It is only a prophecy of what it will be in the future. This is an iron age, or rather the age of steel, which is entering more and more into construction of every sort. Iron and steel are being used and are supplanting wood both on land and on sea. It is supplanting muscle, both of man and beast; being an age of manufacture, the machinery employed in carrying on the great enterprises is made of iron. This is an age of travel, and the railways and the railroads that entwine the earth are made of iron and steel. In this era of commerce, the great ocean freighter and ocean liner are constructed of iron. In spite of all the great peace conferences, this is an age of great and growing navies, and battleships are of iron. It is an age of steam power, and iron is its harness. It is an age of electricity, and iron is the great medium, or conductor. The

supply of iron ore and coal being almost inexhaustible in the United States and Canada, is destined to keep this nation the great manufacturing nation of the world. With the opening of the Isthmian Canal and the awakening of China, whose needs and wants are complemental with ours, from her lethargy, in years to come the Pacific Ocean will be the great highway of commerce. On its waters will be fought the great battles which will determine the rule of absolutism or free institutions for all mankind.

In welcoming the Laundrymen to the city of Pittsburgh recently I told them that they were great uplifters of humanity, and I say to you Foundrymen that through your efforts life has been alleviated of many of its burdens and you have produced the parts of machinery that are carrying civilization to all quarters of the globe. I said to them that "Cleanliness is next to Godliness." Then, again, I hold that a nice, clean laundered shirt and collars and cuffs, and so forth, are something that we should thank God for; and when we send them to their laundries and get them back whole and in good condition, we feel like thanking God again.

I am informed that a gentleman who is sitting nor far distant from me, a Mr. Zimmers, has been appointed a committee of one to show Pittsburgh to you, and dine you, and wine you, and keep you out of jail. Now, I don't believe he will have much of a task on his hands or be diminished of his funds by those who know him, and from experience which we have, I am disposed to turn over to him the city keys—and, at this particular time in our city's history, I would like also to turn over to him a few city "lid-lifters." He is well acquainted with the highways and by-ways of the city of Pittsburgh and I likewise turn over to him the freedom of our city, and I believe that he could steer you along the paths of virtue, avoiding all danger,—and if danger should unaware confront you, he has my telephone number. I understand also that he is thoroughly primed for this occasion, and I turn you over to his tender mercies

Now, the foundrymen have done much for our city and we can never pay the debt of gratitude we owe to them. They have given their time and their energy, and with their wealth and their product they have helped much in the building of our city, and

when we turn the strangers within our gates over to them, we feel that we are placing them among our most esteemed citizens. Last week I welcomed to our city the delegates to the Gas Men's Convention, and I understand that they went out sightseeing and while they were walking down Fourth Avenue one of the visiting gentlemen said to the Pittsburgher: "What street is this?" and the Pittsburgher replied: "Why, this is Fourth Avenue, our Wall Street; this is the home of our bankers and brokers, our real estate men and our stock exchange, and, by the way," said the Pittsburgher, "this is also one of the greatest 'watering places' in the country."

You must spend several hours in sightseeing, and if you do you will find our cultured city possessing all modern improvements. It is a grand old commonwealth, nestling peacefully among the hills of western Pennsylvania—one of the flashing gems on the skeleton hand of Time. Pittsburgh is not progressive to the extent that her people have cast aside humanity and anointed themselves with hypocrisy. She does not give her worthy visitors a cold storage welcome, but rather takes them to her great warm heart and treats them so well that they wish to tarry longer.

Pittsburgh possesses for the poet, philosopher and student an inexpressible charm. The banners of four nations have waved over her battlements. The English and French contended for the supremacy of this country at old Fort Duquesne. Here conferences with the Indians were held, the termination of which raised the banner of Washington, which still proudly fondles our air.

You will be shown many historical places where great achievements have been wrought and when you leave us you will realize that every foot of our city is holy ground. You must visit our libraries and technical institutes, which perpetuate the name of Carnegie; our wonderful steel works and foundries which proclaim Pittsburgh to be the workshop of the world. By all means take an excursion to our South Hills and from them look down upon our city at night with its countless myriads of gleaming lights—one would think that the angels had spilled a basket of stars.

The past, with all its glorious achievements, lies spread out before us in epitome. We can proudly boast of our tireless energy and the genius that gilds our name with glory, but you must not forget that what we are is only a prophecy of what we will be in

the future and when you come among us again our dreams will have become realities and Pittsburgh will be the leading industrial center of the world.

President Speer:—I understand that Buffalo has sent some of the members of its Chamber of Commerce down to Pittsburgh, to see what we are doing. I know that Pittsburgh has one of the most active Chambers of Commerce in the country. We had expected to have its president, Mr. Babcock, here in person to welcome you, but he was unable to come. However, we have a man who can speak for the Chamber fully as well, and enjoys the distinction of being its first Vice-President. I have the honor of introducing to you Mr. Stevenson.

ADDRESS OF MR. STEVENSON.

Ladies and Gentlemen:—You know the speaker cannot take off his coat and enjoy himself like the men in the audience on so hot a day as this, but I am pleased to be here. To me was delegated the pleasant task of extending to the gentlemen of this convention the felicitations of the Chamber of Commerce. Mr. Babcock, the President of the Chamber of Commerce, could not be here and asked me to take his place. Now, he weighs two hundred and fifty pounds in the shade, he is six feet two inches tall and he wears No. 14 shoes, so when he asked me to fill his shoes this morning you can realize at once what a difficult proposition I had, and I know you sympathize with me.

I do not know much about the foundry business, but I do know that you use sand in it, and I have a fellow feeling for the fellow who uses sand in his business because there is a supposition that sand is used in the business I am engaged in, *i. e.*, the grocery business.

At Atlantic City one warm summer day a young lady and gentleman were sitting on the beach and getting closer together every moment, and finally they became a little affectionate and presently the young man made a sort of motion and the young lady said: "My, you shocked me that time; I thought you were going to kiss me." "No," he said, "I wasn't trying to do that;

I got my mouth full of sand," and she said, "Swallow it! You need it in your system." [Laughter and applause.]

Now, I'm satisfied that he was not a member of an organization of this kind, that gentleman must have been a groceryman. [Laughter.] About the only organization at present that I know of that needs sand is the grocers'.

Now, gentlemen, we are very proud that you have selected Pittsburgh as your meeting place this year. We feel that in selecting Pittsburgh you do not believe many of the stories that are printed about the city, but that you believe that Pittsburgh is not as black as she has been painted. Why, we have three-hundred and sixty-five days just like this all through the year; the "Smoky City" is a misnomer; we are giving you a sample of our usual weather, I hope you will enjoy it. I notice the President is smiling at that, but we do other things besides make iron and *steal* for a living in Pittsburgh [laughter] and we want you to ride about our city and see what a beautiful city we have. We want you to visit our magnificent Carnegie Institute and see our splendid Memorial Hall; we want you to ride through our parks and see the glorious scenery and the inspiriting long views of industrial activity. We have three hundred and seventy miles of madacam roads in the county of Allegheny, more than some of the eastern cities have within their entire boundaries. We have a great many things to see and to enjoy, and we believe that if you take the time to see and to enjoy what we have here in Pittsburgh, when you leave and return to your homes you will have many pleasant and profitable memories of your visit to us.

The Chamber of Commerce believes in conventions; it believes in organization, and organizations, no matter whether they are political, commercial or civic, are just what the individuals and members of those organizations make them. The Chamber of Commerce is very glad to extend to you all a hearty welcome to the city of Pittsburgh. Many of you, no doubt, belong to special organizations other than the one you specially represent here, in your own homes,—and we bid every one here a cordial welcome.

We believe that conventions stimulate business. Emerson says that no great thing can be done without enthusiasm; we believe that conventions like this foster enthusiasm and they bring about optimism, which is so essential at the present time. Business

needs the optimist to-day. We all realize that, and we have no use for the pessimist anywhere. The pessimist will get up in the morning and seeing that it is raining, he immediately gets a grouch on and says: "I intended to go to baseball to-day and can't on account of the rain!" The optimist looks out of the window and sees it rain, and he says: "It is raining this morning, but to-morrow the grass will be greener, the skies will be bluer, and the birds' songs will be sweeter; there will not be a baseball game to-day, but to-morrow I will see two games for the price of one ticket!" [Laughter.]

Maeterlinck says that a bee never makes honey alone; it cannot do it. A bee separated from the hive cannot make honey because of its lack of intelligence, but a bee within a hive, a bee working among other bees, has a well-defined purpose and intelligence and meets with success. Maeterlinck calls that "the spirit of the hive," and I believe that is one of the principal thoughts that you have in your organization. That is, to work together and to work for each other's good.

The very heart of all organizations of this kind that you represent here to-day is the fact that it is built upon the co-operation of the members, the mighty help of the members. When an organization is built upon such a foundation there is no question about its success. There is no doubt about the success of your organization and no question about its accomplishing great things for itself and its individual members.

Now, gentlemen, I do not want to take up much longer time in talking to you; I want to extend to you an invitation to visit the Chamber of Commerce rooms. We will be very glad to explain to any of the gentlemen the work of the Chamber of Commerce or any of our organizations of that character and the workings of our Chamber in Pittsburgh. We have accomplished some things; we have a splendid organization; we believe in public-spirited work and in work for the individual member, and we will take pleasure in demonstrating to any of you gentlemen what we can do as far as an organization is concerned, right here.

In conclusion, I only want to say we hope you will enjoy yourselves and that you will come again; we hope you will have such a pleasant time that you will want to have another convention here. I believe you are going to have a good convention and I

am glad we have the facilities for accommodating you in this building. We want you to come back; we will treat you well, and we will treat you often. [Laughter and applause.]

MAJOR SPEER:—Gentlemen, being a Pittsburgher as well as the President of this Association, it would seem very funny to me to reply to the addresses of welcome, I have called on one of our Vice-Presidents to make the reply. I now have the pleasure of introducing to you Mr. Alfred E. Howell, of Nashville, Tenn.

ADDRESS OF MR. HOWELL.

Mr. President, Ladies and Gentlemen:—When I was honored a couple of years ago by being elected Vice-President of the American Foundrymen's Association it was very astonishing to me that anybody south of the Ohio River should be taken notice of in the great industrial field of iron and steel, because you know for decades the South has been devoted nearly altogether to agriculture; so I felt particularly honored in being the only man south of the Ohio River in any official capacity connected with this great association.

Through the American Foundrymen's Association and the American Brass Founders' Association and the literature they had brought out, your work and the names of those who do the work of this convention have become by-words in the South. They are so well known to those who are studious and attentive and careful for the future progress of their industry.

So I take particular pleasure in voicing for the convention our appreciation of these very kind words of welcome from the representatives of the city of Pittsburgh, the Mayor and the Chamber of Commerce. And I want to say to you that the name of our honored president, Major Speer, has become a well-known word among all your foundrymen, and those interested in our foundry affairs, as have also the names of the past officers of this association, those who have made themselves well known through their writings and in other ways of interest and of value to the Association and its members.

Now, gentlemen, I do not feel that your time should be taken up by desultory remarks, but I do want to say that we appreciate

most thoroughly the welcome that has been accorded us, and representing, as we do, the whole field—East, West, North and South—we are all grateful to Pittsburgh and look upon it with admiration. We are glad that the Allied Foundrymen's Associations are holding their conventions here.

PRESIDENTIAL ADDRESS.

MAJOR SPEER:

Gentlemen, Members of the American Foundrymen's Association, Brass Founders' Association, Foundry Foremen's Association and Foundry & Machine Exhibit Company:—I consider it a great honor to open this, the Sixteenth Annual Convention of the American Foundrymen's Association. I do not propose at this time to go into a review of the great work accomplished by this organization in the past, as it would take up too much valuable time, and you are all doubtless aware that if it had not been for our organization the foundry industry would not be what it is to-day.

One of the most astonishing things, to my mind, is the fact that such a large number of foundrymen will come from all parts to attend these annual meetings, showing that we are all deeply interested in the science and art of the business. Let us go back for a moment to the time when the foundryman made a mystery of his business and what little knowledge he obtained by experience he kept to himself. In those days our pig iron was graded by fracture, melted in an air furnace from which the molten iron had to be dipped through an opening in the top. In those times everything about a foundry was run by rule of thumb. These conditions began to improve, but had advanced but little up to the first meeting of the American Foundrymen's Association held in Philadelphia in 1896, and it is not necessary for me at this time to point out the wonderful advancement that has been made since our first convention. The science of doing things and how to do them has been given to the world by our past conventions and the art of doing things is a wonderful advancement in the trade to-day.

I would like at this point to compliment and thank Mr. H. E.

Field and his committee on papers, also our worthy secretary, Dr. Moldenke, for the great diligence and interest shown in the securing of papers which are to be presented for your consideration at this meeting.

During the past year remarkable strides have been made in advancement of the trade, not only through educational lines, but also in the perfecting of machines and appliances, this being fully illustrated by the magnificent display made in this building by the Foundry & Machine Exhibit Company. The conditions of the foundry industry to-day have been caused, in my opinion, by a combination of circumstances which I cannot recall ever having occurred before in my business experience. The prosperous business of 1906 and 1907, as we all remember, was followed by a panic which commenced in the autumn of 1907 and continued through the year 1908 and was succeeded by a fictitious boom early in 1909 which resulted in a large advance in wages and an increased producing capacity. It soon developed that the country at large was not ready for the improvement, and after struggling along for almost two years we find ourselves to-day face to face with business conditions almost as bad as in October, 1907, except from a financial standpoint. In addition to this the changed political conditions of the country which indicate a complete revolution in regard to the tariff, the unrest of labor, the probability of a sufficient number of the state legislatures fighting for an amendment to the Constitution of the United States authorizing Congress to levy an income tax, the time fast approaching for the Presidential election of 1912, together with other conditions which will finally arise, to my mind account largely for the position in which we find our business to-day. Let us take courage, however, and exercise extra caution until the storm is over and with brave hearts face the future with the full belief that there are good times in store for us yet.

Mr. Olsen, Vice-President of the American Brass Founders' Association, then read his address, which is reported in the Transactions of that Association.

Secretary Moldenke then announced that he had received word of the sudden death of an old member of the Association,

Mr. W. W. Sly, of Cleveland, and had sent the following telegram to his family:—

"The many loving friends of Mr. Sly send their profoundest sympathy and heartfelt condolences, and commend his bereaved family to the mercy of the Almighty." The American Foundrymen's Association, Richard Moldenke, Secretary.

Mr. Lane:—Mr. President, we have all known Mr. Sly for a good many years, and I do not believe the announcement of his death should pass without our having something entered on our records to show our sympathy with his family and our deep appreciation of his valuable services and friendly interest.

I wish also to announce the death of Mr. Alfred N. Spencer, who died on Thursday. While Mr. Spencer was not as well known as Mr. Sly, he was very well known to many of us, particularly on account of his active interest and large exhibits at our conventions. I believe we should honor the memory of both of these members, and therefore make a motion that the President appoint a committee of three to draft resolutions expressive of our sympathy and in honor of the memory of these two members and that copies of these resolutions be forwarded to the respective families.

Mr. A. W. White:—Mr. President, knowing Mr. Sly, as I had the honor to, very well, and also Mr. Spencer, whom I met in many of our conventions, and having a very high regard for both of these gentlemen, I second the motion. I do this, coming from Canada, because we in Canada who knew Mr. Sly probably as well as you in the United States did, had a very kindly feeling for him. When he was over in Toronto, in Buffalo, Detroit and Philadelphia, we met him, and we wish to show our admiration and respect for his memory as also for that of Mr. Spencer. We were particularly interested in Mr. Sly both on his own account and because of his interesting large exhibits.

The motion was duly carried. President Speer appointed as members of the committee Mr. Lane, Mr. White, and the Secretary.

The resolutions were subsequently drafted, engrossed and forwarded to the families of the deceased members.

The secretary-treasurer, Dr. Richard Moldenke, next read his report, as follows:—

REPORT OF THE SECRETARY-TREASURER.

Your secretary is happy to report that the affairs of the Association are in a flourishing condition. The recent increase in the annual dues, while reducing the membership in the Association somewhat, has placed it upon a sound financial basis, so that there need be no hesitancy in expanding the work of the Association, and thereby increasing its usefulness to the membership and the industry at large.

For the first time in the history of the Association, its Transactions have been sent to the membership in bound form, in addition to the usual pamphlets, and a substantial volume of nearly 500 pages formed the record of the splendid Detroit Convention of last June. So great was the demand for Dr. Porter's exhaustive report on the "Chemistry of Cast Iron," that the very few additional copies struck off, and only allowed to go out by subscription to members, were quickly exhausted. The same can be said of a number of the other papers presented, all of which indicates a healthy desire on the part of foundrymen to keep informed.

The present slackness in our establishments has had the usual result of stimulating investigation along the lines of effective economy, and the mail of your secretary's office has reflected this most voluminously. The awakening of cities to the smoke problem has also seriously embarrassed many foundries, and it is respectfully suggested to our supply houses to get busy and devise ways and means to wash the gases emanating from the cupola, so that an ever-growing problem may be met.

The year has seen much progress along lines of continuous melting, the permanent mold, and perhaps the distinctive feature has been activity along the lines of utilizing waste metals in the foundry. Whether by briquetting or special methods of melting to avoid undue oxidation, the problem has been solved, and awaits only proper introduction to the industry.

The special investigations carried on by the Association have not been neglected. You will have before you a paper on the action of titanium on "Malleable" presented by our member

Mr. Gale, and Mr. Field will also bring before us a short criticism of the molding sand tests so far carried out, his laboratory having been good enough to give us all the chemical data required.

Most of the physical tests on the eighty-odd molding sands have been completed, and considering that this meant over 1500 separate tests, the magnitude of the work can be imagined. In addition, the Ohio State Geological Survey requested our Association to add to this investigation the complete series of molding sands of that State, which meant a further 850 tests.

It will still take some time to digest and complete this work, and then a report will be issued on the subject of molding sand. Your secretary looked after this work, aided by three assistants for the time being.

The Association is highly indebted to the Committee on Papers created at the Detroit Convention. Particular thanks are due the chairman, Mr. H. E. Field, for his activity and success in getting valuable papers for this convention. Your secretary sincerely hopes that the committee will be continued. The indulgence of the convention is asked for the incompleteness of the printed matter distributed at this time. Whether the secretaries of other organizations have similar difficulty in getting the good writers of papers to complete their task in fair time is not known, but when it is stated here that on March 1st only one paper was in the hands of your secretary, and the outlook for more very gloomy, and this in spite of an early campaign, the fact that the programme has forty-three separate items shows that interest comes late and all bunched together. The result is that the nerves of the secretary, the managers of two big printing houses, artists, engravers, etc., are in tatters, and only half of the papers in print and ready here, with more coming every day during the convention.

The instructions adopted at the Detroit Convention have all been duly carried out. A new membership list has been issued, and as funds are now available, will be gotten out each year.

At the time of this report the membership of the Association in good standing was 692. This will probably be reduced somewhat when the arrangement with the members of the former Supply Association ceases, July 1st. We have, however, every reason to congratulate ourselves upon the growing interest manifested in our work, for in spite of what may be said of the

origin and development of the foundry revolution of recent years, this has been the actual work of our individual members, and has had the hearty backing of the Association as a body.

The financial statement for the year is as follows:—

RECEIPTS.

Balance	$268.53	
Dues and subscriptions	5,085.50	
Interest	40.18	
		$5,394.21

DISBURSEMENTS.

Transactions	$2,100.27	
Printing	138.60	
Convention expenses	233.85	
Salaries	1,100.00	
Postage	437.00	
Sundries	43.79	
		$4,053.51
Balance		$1,340.70
Special fund		201.25
Total		$1,541.95

Respectfully submitted,

RICHARD MOLDENKE,
Secretary-Treasurer.

May 20, 1911.

Mr. W. M. Corse, secretary-treasurer of the American Brass Founders' Association, then read his report, which may be found in the Transactions of that Association.

President Speer then announced the papers for the session. Mr. A. W. Walker spoke briefly in abstract of his elaborate and thorough paper on "Economical Insurance for Foundry Properties."

Mr. Ellsworth M. Taylor next read his paper on "Production Cost." This paper has been particularly called for by foundrymen all over the country, as the subject of costs seems inexhaustible.

Mr. S. E. Nold read his paper on "Why Cost Systems Fail." The secretary briefly reviewed the paper by Mr. C. E. Knoeppel on the "Efficiency Movement in the Foundry," and his own paper on the test bar question.

All these and subsequent papers are printed in full in the beginning of this volume.

Convention adjourned to 2.30 o'clock P. M., the same day.

SECOND SESSION.—TUESDAY, MAY 23, 2.30 P. M.

The Convention was called to order at 2.30 P. M., May 23d, by President Speer, who introduced Mr. P. Munnoch, formerly of England, as the first speaker. Mr. Munnoch read his paper on "Cupola Melting Practice."

This paper was followed by another paper on "Cupola Practice," by Mr. R. H. Palmer, of Salem, O., and both papers were discussed together. The discussion will be found in a previous portion of this volume.

Dr. Moldenke next presented his paper on the "Briquetting of Metal Borings." He illustrated it with a number of lantern slides made of photographs taken while in Europe. The paper will be found elsewhere in this volume. It was discussed very briefly.

The next paper was on the "Mechanical Charging of the Cupola," by G. R. Brandon, of Harvey, Ill. This was profusely illustrated by lantern slides, reproductions of which will be found in the printed paper. The paper was discussed briefly, as may be noted in a previous part of this volume.

Dr. Moldenke next gave an extract of Mr. Nau's paper on recent "Progress in Heated Foundry Mixers," and called special attention to the fact that molten gray iron had been held for the greater part of the day without change in composition, by the simple expedient of adding carbon to the slag covering.

Mr. Charles Slocum next read his paper on "Titanium in Iron Castings." A short discussion appears elsewhere.

Mr. E. H. Mumford, of Plainfield, N. J., next discussed "Molding Machine Practice" at length, the paper being printed in the early part of the volume. Mr. John Alexander, of Philadelphia, Pa., then took up the subject of "Machine *vs.* Hand Molding," and discussed the practical side of this large subject. Both papers will repay a careful study.

The Convention then adjourned to the following day.

THIRD SESSION.—WEDNESDAY, MAY 24, 9.30 A. M.

A joint session of the American Foundrymen's Association and the American Brass Founders' Association was held in the morning, and was called to order by President Speer at 9.30 A. M. A paper by Dr. W. R. Whitney, on "Alloys" was read by Secretary Corse, of the Brass Founders' Association. Mr. Thomas D. West then read a short paper on the "Prevention of Accidents by Fire." This was not discussed.

Mr. Edgar A. Custer was now given the floor to read his paper on the "Permanent Mold," being in continuation of a former paper on the same subject, read at the Cincinnati Convention. The subject was thus brought up to date. The elaborate discussion of this paper will be found in another part of the volume.

Mr. Benjamin D. Fuller was next introduced by President Speer, and read his paper on "The Foundry at Close Range." He prefaced his paper as follows:

Mr. President and Members of the Association:—I will read my little paper and talk to you on the subject of the foundry; but I may be placed in the position of a Scotchman who was taken to task by his pastor for not coming to church. He said: "Well, Dominie, why should I go to church? In the first place you read your sermon, in the second place you do not read it well, and in the third place, it is not worth your reading." [Laughter.] I will try to make it as interesting as possible.

The paper covered the ground so thoroughly and well that it was not discussed.

President Thompson, of the Associated Foundry Foremen, was given the courtesy of the floor, and made announcement of the dinner to be given in the evening to the visiting Foremen, by the Pittsburgh Foundrymen's Association.

President Speer then introduced Mr. Archie M. Loudon, who read his paper on "Core Making and Core Machines." Owing to lack of time this highly interesting paper could not be discussed.

Mr. Coleman's paper on "Core Room Practice" could not be given, as, owing to delays on the part of the express company, a large collection of lantern slides for this elaborate paper were not at hand at either this time or during the remainder of the

convention. The paper has since been published and forms part of this volume.

The Secretary then gave an abstract of Mr. Capron's paper on the "Recovery of Foundry Waste," and exhibited the samples of sand in various stages sent in by the author, who found it impossible at the last moment to attend.

The last paper of the session was given by Mr. S. H. Stupakoff, on "Pyrometry," and before giving a brief abstract of the paper in question, the speaker prefaced this by a general talk on the subject, which proved so instructive that he was subsequently prevailed upon to elaborate the stenographic report, and make another paper of the extempore remarks. This paper is given in another part of the volume.

The meeting then adjourned to the afternoon.

FOURTH SESSION.—WEDNESDAY, MAY 24, 2 P. M.

President Speer called the convention to order, and introduced Mr. R. E. Bull, who read his elaborate paper on "Open Hearth Steel Practice." This was thoroughly discussed, as published in another part of this volume.

Prof. Bradley Stoughton next read his two papers on the "Manufacture and Annealing of Converter Steel Castings."

The Secretary next read Mr. Walter McGreggor's paper on "The Small Open Hearth Furnace for Steel Castings," in the absence of the author.

Mr. C. H. Vom Baur then read his paper on "The Practicability of the Induction Furnace for the Making of Steel Castings." This paper was accompanied by a large number of lantern slides.

Prof. William Campbell, in delivering his lecture on the "Microstructure of Iron and Steel," gave a running account of the subject based upon some eighty lantern slides. The paper is fully illustrated, as printed in another part of the volume, and has since become standard for the class-rooms of a great university.

The Secretary next gave an abstract of Dr. Heroult's paper on the "Electric Furnace for Steel Castings," upon which Mr. Charles V. Slocum read his paper on "Titanium in Steel Castings."

The convention then adjourned until the following day.

FIFTH SESSION.—THURSDAY MORNING, MAY 25th.

The convention was called to order by President Speer, who introduced Mr. G. L. Norris, as the first speaker. Mr. Norris discoursed on "Vanadium in Iron and Steel Castings." A spirited discussion followed, the substance of which is given in another place.

The Secretary next gave an abstract of Mr. George K. Hooper's paper on "Foundry Construction."

Mr. Brent Wiley was next given the floor by President Speer, and read his interesting paper on "Electric Motor Drive for Foundries." This paper is copiously illustrated and published with the others.

Mr. R. H. Rice then read his paper on "The Rotary Blower for Cupola Use," which was well received, and has since had a heavy call from interested foundrymen.

"The Application of Lifting Magnets for Foundry Works" was the title of the next paper, read by Mr. H. F. Stratton. A considerable discussion resulted; as much as could be caught in the noisy room being found in another portion of this volume.

President Speer then appointed the following Committees:—

On Nomination of Officers for the Ensuing Year.—Messrs. W. H. McFadden, L. L. Anthes, A. F. Waterfall, E. H. Mumford, and A. E. Howell.

On Auditing the Books of the Treasurer.—Messrs. William Yagle and William A. Bole.

On Papers.—Messrs. R. E. Bull, L. L. Anthes, A. O. Backert, and E. M. Taylor. This committee to work with the Secretary to provide for a substantial programme at the convention to come.

Mr. W. S. Giele then presented his voluminous and entirely admirable paper on "Pattern Equipment." This paper is some hundred pages in length, and will repay close perusal, as giving the latest on the subject. It is to be found in the early part of the volume.

The paper by Mr. C. H. Gale, on "Titanium in Malleable," and the one by Mr. N. W. Best, on "The Equipment of Air Furnaces using Oil as Fuel," were postponed until Friday, owing to the lateness of the day.

Secretary Moldenke announced that as the lantern was ready for use, it had been decided to ask Mr. W. P. Putnam to present his paper on the subject of "Physical and Chemical Characteristics of Malleable Iron" now, as there were a number of illustrations accompanying it.

MR. PUTNAM:—I expect to show you the result of only a few experiments I have conducted from time to time in the last few years in regard to the annealing of malleable castings, and what can be done by checking up your results by means of a microscope.

The first requisite in the annealing of malleable iron, as you all know, is to get the correct temperature, and in order to get this for special work it is necessary to know the critical temperature of the iron that you are to anneal. To do this we determine the proper actual temperature as well as the critical temperature of a series of malleable castings. The first slide illustrates graphically the temperatures we have determined to be accurate for malleable castings of a certain grade.

Mr. Putnam then showed his lantern slides and illustrated and explained in detail his experiments and their result. Mr. Putnam's paper in its entirety will be found in the early portion of the volume.

A short discussion followed and the Convention then adjourned to Friday, May 26th.

TRAIN EXCURSION TO FOUNDRIES AND STEEL WORKS.

The afternoon of May 25th was given over to a big excursion by train, about 660 members attending. The gathering started off at 1 P. M., and was first taken to the plant of the Westinghouse Air Brake Company, where the wonderful foundry was thoroughly inspected. This foundry has the series of revolving train of cars which carry the molds. Continuous pouring is practiced, and the daily tonnage is enormous when running full. The sand system is most complete, and the operations go on without a hitch.

From here, the train went to Homestead, where the great mills of the Carnegie Steel Company were visited, and the girder mills, armor plate forming, hardening, and erecting shops were thrown open. The open hearth furnaces were also seen in full operation, making large heats of basic steel.

After leaving the Homestead Mills, the train was switched to the Mesta Machine Company's plant, where a modern steel and iron foundry was inspected. The heats were being poured off at the time, and the shop was full of ponderous rolling mill equipment and engines in all stages of erection. The train was then taken back to the city, and every one voted that he had had a most instructive afternoon.

Entertainment of the Exhibition Company.

On the evening of May 25th, a splendid entertainment was given by the Exhibition Company to all those who attended the Convention and their guests. The large Music Hall of the Exhibition was used, and the evening filled with vaudeville talent, Singing Society music of the finest kind, and a general and high-class entertainment which delighted all who were fortunate enough to attend.

Sixth Session.—May 26, 9.30 A. M. Final Session.

President Speer called the convention to order at 9.30 A. M., and presented Past President Thomas D. West, who read an elaborate paper on "Gas Cavities, Shot, and Chilled Iron in Castings." The discussion of this interesting paper will be found in another place.

Mr. C. H. Gale then read his paper on "Titanium in Malleable," which elicited much discussion. This will be found with the other discussions in another part of the volume.

The Secretary gave abstracts of Mr. Outerbridge's paper on "Manganese and Silicon in the Foundry," Mr. Wilson's paper on "The Foundry Foremen's Educational Movement," and Mr. Field's "Instruction Paper on Phosphorus."

This closed the papers and discussions arranged for the Convention.

Major Speer then stated that the next business of the Convention would be the listening to reports of committees.

The Auditing Committee reported that they had examined the books of the Secretary-Treasurer for the two years, and found them correct. They presented a written and signed report.

The Nominating Committee, through its chairman, Mr.

McFadden, then presented the name of Major Joseph T. Speer for President of the American Foundrymen's Association for the year 1911–12.

On motion, seconded and unanimously agreed to, Secretary Moldenke was directed to cast the ballot of the convention for Major Speer for President. This was done amid much applause.

In response to requests for a speech, Major Speer said:—I do not know what to say to you. I was very much surprised the other morning when I saw in the daily papers that my name was mentioned for the office of president again, which was the first inkling I had of such a movement. I cannot say anything to you to express my appreciation of your confidence. I tried to do my duty, and, as I said to you in Detroit, I will try to continue to do my duty. If there are any mistakes made I hope all the members will know that they are from the head and not from the heart.

The Nominating Committee then presented the other names for officers of the Association, as follows:

For Vice-Presidents:—

F. B. Farnsworth, McLagon Foundry Co., New Haven, Conn.

W. D. Miles, Buffalo Foundry and Machine Co., Buffalo, N. Y.

Walter Wood, R. D. Wood & Co., Philadelphia, Pa.

A. E. Howell, Phillips & Buttorff Manufacturing Co., Nashville, Tenn.

R. E. Bull, Commonwealth Steel Co., Granite City, Ill.

T. W. Sheriff, Sheriff's Manufacturing Co., Milwaukee, Wis.

D. R. Lombard, Lombard Iron Works and Supply Co., Augusta, Ga.

S. B. Chadsey, Massey-Harris Co., Toronto, Ont.

On motion, duly seconded, the Secretary was instructed to cast one ballot for the above gentlemen, who were thereupon declared elected.

Mr. Alfred E. Howell then made a motion, duly seconded, that the by-laws or the Constitution be amended so that a Standing Advisory Committee, consisting of the past presidents of this Association, shall be established, the members of this Advisory Committee to be *ex-officio* members of the Executive Committee.

Motion seconded and carried unanimously.

Mr. Seaman:—Mr. Chairman, I was under the impression that the Executive Committee attended to the selection of a meeting place of the annual convention, but by reference to the by-laws I find that is not the case. Therefore I respectfully move that the annual convention of this Association be held in the city of Buffalo, N. Y., in 1912. Motion seconded.

President Speer:—We have letters from several citizens of Buffalo and quite a mass of literature has been sent us, also an invitation from the Mayor of Buffalo, an invitation from the Chamber of Commerce, an invitation from the Manufacturers' Club of Buffalo, and invitations from several other clubs and organizations of that city. Mr. Tracy, of the Chamber of Commerce of Buffalo, is here in person and I will call on him to make his plea for Buffalo as the next meeting place of our convention.

Mr. McFadden:—Mr. Chairman, in order to get this question before the meeting as it should be, while I do not wish to interrupt Mr. Tracy, I think it might be advisable, as there is some talk of other cities, to ask for a discussion on the motion as put, and let it go in that form; any remarks to the contrary would be in order to follow Mr. Tracy's address on the subject.

Dr. Moldenke:—We have invitations to hold our next annual convention in about sixteen different cities; we even have an invitation from a city which boasts of "a magnificent distillery;" but actual work along this line has only been done by Buffalo. Milwaukee, however, also asks for the convention.

Mr. McFadden:—My desire, Mr. Chairman, is simply to ask for remarks and not to designate Mr. Tracy as the only individual to represent but one city when there are fifteen or sixteen other cities that have sent invitations to us. Let Mr. Tracy represent his city, and if the other cities are not represented I presume there will be no one here to speak for them. We can then take action.

President Speer:—Mr. Tracy seems to be in a majority of one, and I have great pleasure in introducing him to you as the representative of the Chamber of Commerce of Buffalo.

Mr. Tracy spoke as follows:

Mr. President and Gentlemen present:—Before proceeding I want to thank the Chair for the kindness extended me, and for

the many courtesies shown me by the different officers of this organization from the time I started the correspondence with you regarding your convention for 1912, which we all hoped would be in Buffalo. And if I may be permitted I would like to compliment the Pittsburgh committee for the way they have handled this convention, and to express my thanks for the many courtesies this committee has extended me, and all those with whom I have come in contact while I have been here. I think they deserve the greatest praise for the way the convention has been carried on.

I would like to tell you, if you will permit me, also, who I am. I do not come to you as a paid representative of any institution. I am a very minor individual in the city of Buffalo, and come to you as a citizen only, being a member of the Convention Committee of the Chamber of Commerce and Manufacturers' Club of Buffalo, an organization composed of practically 3300 members.

That organization has looked you up; they appreciate the value of your convention; they know what it means to the city of Buffalo, and that is the reason this Committee and myself have been working constantly for the past three or four months toward the end that I hope to achieve here to-day before I leave this room.

Our selfish interest in asking you to Buffalo is to show you what we have in the city both as a business proposition and as a residential city. Buffalo has many things to attract you. We believe it is a proper place for any man in business to locate, any man who wants to select a suitable home for his family,—and I could talk to you the rest of the day on the advantages we offer and the selfish interest that brings me here to see you to-day.

I have presented to your President, as he has told you, letters of invitation from the Mayor of our city, from the President of the Chamber of Commerce and Manufacturers' Club, from several of the leading hotels, and all want you to come to Buffalo in 1912, believing they can take care of your interests properly at that time.

Now, you have had people approach you many times in an effort to secure your convention, with propositions such as your Secretary has mentioned to-day, but I do not believe it is necessary to come to you with any bribe or any gift in order to attract you to Buffalo. I believe we have a business proposition to offer

you, something which your sound common sense will lead you to consider and eventually select Buffalo for.

In the first place we have accessibility, for visitors and exhibitors. There are 250 trains coming into Buffalo daily, and you can leave the city on fourteen boat lines if you wish. Buffalo is within a night's ride of over half of the population of the United States and two-thirds of that of Canada. It has unexcelled location and transportation facilities, both for freight and passengers.

Our hotel accommodations are unsurpassed by any city anywhere near Buffalo's size, and your President and Secretary have a complete list of those hotels, showing the accommodation we can offer you as well as the rates, with guarantees that there can be no increase in rates imposed on you. Our organization is practically under contract with these different hotels to guarantee satisfaction to the delegates in attendance at the conventions in Buffalo; which you will agree with me is a very large item to be considered.

I have appeared before the Executive Committee of the Foundry Exhibition and Machine Company and they have voted to accept our proposition subject to verification by a special committee appointed by them to visit Buffalo and look over our exhibition facilities, which I am perfectly satisfied means that Buffalo will be considered favorably by the Exhibition Company.

I want to say a word to you about Buffalo's climate. Buffalo stands by itself for moderate temperature during the last forty-five years, having ninety-five degrees as the maximum; and second of the large cities in wind velocity during June, July and August, being favored by Lake Erie's cooling breezes. During the three weeks ending August 22, 1896, over two thousand known deaths resulted from sunstroke in the United States, and during that time Buffalo's temperature never exceeded eighty-five degrees, and dropped as low as sixty-five degrees, with only two deaths from sunstroke, and those were the only two of the year.

Out of a possible three hundred times covering a period of ten years the thermometer in Buffalo reached ninety degrees or above only twenty times, being the lowest city in the United States; the temperature in some of the cities reaching ninety-five degrees or higher three hundred times, notably Milwaukee one

hundred times, Chicago one hundred and twenty times, and those cities, I believe, are some of my competitors.

I will say for your information that these statistics are taken from the United States Weather Bureau and submitted to the government, so they should be authentic.

Our hotels, depots, exhibition and amusement places are all within a radius of a quarter of a mile, being within ten minutes' walk from any point you wish to reach, and our trolley service is exceptionally good, cars passing by all the hotels and going direct to the exhibition places.

Buffalo has made great strides in the iron and steel industries since your last visit in 1901, and can now claim the largest independent steel plant in the world. Buffalo plants own their own mines and their own fleets with which to bring the ore to those plants, carrying over 5,000,000 tons per annum. Last year Buffalo plants produced over a million and a half tons of pig iron, and consumed nine million tons of coal to manufacture the coke needed for reduction purposes. We have nineteen blast furnaces with contracts let for two more, eleven of those being merchant furnaces engaged in the manufacture of general foundry pig iron, and every kind of goods that may be required can be got from the various manufacturies in this district.

Buffalo has the largest linseed oil plant in the world. Buffalo has the largest coal trestle in the world, being that of the Lackawanna Company, which is over a mile long. Buffalo will be the excursion district of the United States, it is now its holiday excursion district. Immediately accessible to Buffalo are all the Canadian points of interest which appeal to the summer excursionists, not the least of which is Niagara Falls

Buffalo abounds in lake and river resorts, being surrounded by water on three sides, and the boating and side trips that can be taken from Buffalo are very attractive, and offer a sane and pleasant form of amusement. We have four different boat clubs, and among the forms of entertainment we have to offer you will be some of the best motor boat races you probably have ever seen in any resort.

Buffalo is conceded to have one of the best equipped automobile clubs of any city in the country. The new home of that club is located on eighty acres of land within eighteen miles of Buffalo,

and is reached by the very best brick pavement and macadam roads. That makes another point of entertainment which will appeal particularly to the ladies.

Buffalo has one thousand acres of very well kept parks within a very short distance of the city, in fact some of those parks are scattered throughout the city, and these will give breathing places during the day and evening to our visitors as they do to our residents.

Niagara Falls I have mentioned and you realize that that is one of the scenic points of interest of the world. I will not attempt to tell you how many visitors go to Niagara Falls every year, but it is close to a million,—at least that is the information I have at present.

Now, gentlemen, the city of Buffalo wants you, its people want you, the Chamber of Commerce and Manufacturers' Club want you; the local foundry interests have made preparation for your entertainment and they are very anxious to receive you and to extend to you the right hand of hospitality; and I am satisfied, gentlemen, if you decide in favor of Buffalo, that you will all look back with great pleasure to your visit to our beautiful city and think of it as one giving both education and profit, not to say a great deal of pleasure.

President Speer:—I would like to ask if there are any other gentlemen here who wish to be accorded the privileges of the floor in order to present the advantages of any other city or cities? The floor is open to any gentlemen who wish to speak. No one responding, Mr. McFadden offered a motion to close the debate and the question be put and that a rising vote be taken. Seconded and agreed to.

President Speer then put the motion offered by Mr. Seaman, that Buffalo be chosen as the place of holding the next annual convention of the American Foundrymen's Association, and a rising vote showed it to be carried unanimously.

Mr. McFadden:—Mr. President, I would like to ask that you revert back to the nomination and election of officers. Your capable secretary, who is always so anxious to do much in a short time, encroached on the Nominating Committee's plans, and sort of side-stepped them, and now we want him to sit down a little while.

We want to make a little bit of a distinction in presenting the nomination of officers, separating out the secretary-treasurer, and we also talked over the idea of passing a resolution in connection with the secretary-treasurer's nomination. Now getting this new convention business before the house before the Nominating Committee was through with its work rather upset it, and I would like to have the convention revert back to the election of officers.

PRESIDENT SPEER:—By all means, go ahead, Mr. McFadden.

MR. McFADDEN:—The Nominating Committee takes great pleasure, Mr. President, in presenting and recommending Dr. Richard Moldenke as the Secretary-Treasurer of the American Foundrymen's Association, and also asks that a resolution be received in the form of a vote of thanks, Mr. Anthes of Toronto presenting this resolution.

MR. ANTHES:—Mr. President, I do not know just exactly how Mr. McFadden wishes me to word my resolution; I have a resolution to present first, and then I will spread myself a bit, as Mr. McFadden does.

Now, gentlemen, I suppose each and every one of us has felt more than gratified at the magnificent way in which this convention has been handled in Pittsburgh. As our friend Mr. McFadden says, there is a debt of gratitude from this Association to its friend and officer, Dr. Moldenke. He has been a very warm friend of mine ever since my first meeting in Cincinnati years ago, and every year I always feel somewhat inspired in getting on my feet and offering a special tribute to our very good friend and champion,—a man who has probably done more individual work than any other man in the world towards the betterment and advancement of foundry practice and foundry interests. And in passing, I think there ought to be a tribute paid to the chairman of the Committee on Papers—(it is hardly my place to comment on that committee, having been a member of it myself)—I will say that the onus of the work has certainly fallen on the shoulders of the chairman, Mr. Field. He has certainly been energetic in getting together one of the finest lot of papers ever brought before one of our conventions. Mr. Field has not only been energetic in getting the papers together, but in the registry and the many little arrangements made in the city for the interest, education and entertainment of the delegates. We all feel that we owe to Mr.

Field a deep debt of gratitude. I am sorry he is not here to say a word or two in response to this. Of course he is a very modest young man, like Mr. McFadden and myself, and probably would not want to say anything.

We have also to convey our thanks to the different committees and the Associations in and around Pittsburgh for the very able, interesting and entertaining way in which they have perfected the details for the convention of the American Foundrymen's Association.

I now have the honor to present formally for the Nominating Committee the name of Dr. Richard Moldenke for the office of Secretary-Treasurer of the American Foundrymen's Association for the coming year, 1911–12.

MR. McFADDEN:—I move that the nominations close and that Dr. Moldenke be elected by acclamation.

This was seconded and agreed to, and Dr. Moldenke was unanimously and by acclamation re-elected Secretary-Treasurer, and given an ovation.

DR. MOLDENKE:

Mr. Chairman and Friends:—I believe this is about the eleventh time I have been elected Secretary-Treasurer, and I will say as I have said every time before, I will try to do better the coming year than I did this year. This time I am glad to see you have made a separation between the sheep—the officers, and myself—the goat.

MR. HOWELL:—Mr. President, I move the adoption of the resolution of Mr. Anthes, voicing the sentiments of appreciation which he so well expressed and which have been expressed by all in this meeting.

This was seconded.

PRESIDENT SPEER:—The Chair would like to say a word on that motion, gentlemen. It has been my pleasure to be associated with Mr. Field for several years past in our little local association, the Pittsburgh Foundrymen's Association. I have always found him willing to do anything and everything that he possibly could for the foundry interests, not only for our local interests, but for the National, in other words, the American Foundrymen's Association.

It was with a great deal of relief from anxiety that I got him

to say that he would serve this year as Chairman of the Committee on Papers. As you all know, we have been trying to interest the Steel Founders in our convention and have asked them from time to time to present papers on the subject of steel castings, and it is only through the efforts of Mr. Field and his committee that we were able this year to have the interesting papers that we have on that subject. As I said at the end of that session the other day, we have opened the door and we have stuck a stick in it, and we expect next year to have a better set of papers than we had this year from the Steel Founders.

The Steel Founders found themselves in the position we found ourselves some sixteen years ago, and they had their trade secrets and mysteries, the same as we had, and neither of us cared to give them up to our fellow founders. We learned to give ours up for our mutual benefit, and I think they have come to realize that we are such a great educational association that they too are going to come forward and leave their door wide open.

I am getting a little bit off the subject, I know, but I wanted to express my sincere thanks and appreciation of Mr. Field's work during the past year. You have all heard Mr. Anthes' resolution and the motion made by Mr. McFadden and seconded, that it be adopted, what is your pleasure?

The motion being thus put, it was carried unanimously.

Mr. Putnam:—Mr. President, it seems to me that while this motion just carried is highly appropriate, we should not overlook the splendid way the Visitation Committee has taken care of us and the hospitality that has been extended us by the manufacturing establishments which have opened their doors to the members of this Association and the convention. I therefore give myself the pleasure of moving that the convention extend a vote of thanks to the able Visitation Committee and to the manufacturers who have opened the doors of their establishments for our inspection.

This was seconded and carried unanimously.

President Speer:—I would like to offer a motion, if I may be privileged, that the convention give a hearty vote of thanks to the writers of the able papers that have been presented to us in our convention.

This was seconded by Mr. Smith and was carried unanimously.

Mr. Putnam:—Mr. President, I would like to bring up a matter that should have been brought up at the opening meeting, but, unfortunately, I was not at that meeting, but with your permission I would like to present it here.

We all know there is a great diversity in the form of analyses and reports issued by different institutions, and a movement has been put on foot by the Society of Automobile Engineers looking towards the adoption of uniform report cards. The Brass Founders' Association a few moments ago decided to appoint a committee to confer with this committee from the Society of Automobile Engineers, and I would like to see a similar committee appointed from this convention; I think there could be a great deal of good work done.

I therefore, Mr. President, move that the American Foundrymen's Association appoint a committee to confer with the committee from the Society of Automobile Engineers and the Brass Founders' Association on the subject of the adoption of uniform report cards.

This was seconded and was carried unanimously.

Mr. W. P. Putnam was appointed chairman of this committee, and associated with him Messrs. H. E. Diller, M. P. Davis, and George C. Davis.

Dr. Moldenke:—Mr. President, I ask to have it recorded on the minutes of this convention that as secretary I have received two requests from cities which wish to have our convention in 1913,—namely, Milwaukee and Boston. Those two cities wish to be put on record as having asked for the annual convention of this association in 1913.

Mr. Howell:—Mr. President, on behalf of the representative representing the district that takes in St. Louis, I wish to say that St. Louis also wants to be put on record as asking for the convention of the American Foundrymen's Association in 1913.

President Speer:—We have about concluded our business, I believe, but before we adjourn I would like to have a word from the Father of our Association, Mr. Seaman.

This suggestion was received with applause and Mr. Seaman was asked to make a speech. In acknowledgment he said:

I am afraid, gentlemen, that our worthy President is taking me to be a man like himself. There is a man who I have been afraid

would not be recognized as fully as he ought to be. If you all knew Major Speer as well as I know him, you would have a good bit more to say about him. There is a man who has given his close attention to your business during the last year; a man who has a heart in him so large that the Almighty in creating him had to create a large body to hold it. [Laughter and applause.]

Now, I believe I have said about as much as I can say, in favor of Major Speer or on any other subject. Our convention has been a success here and I hope we shall all live to get to Buffalo next year and have as pleasant a time there as we have had here. [Applause.]

On motion, convention adjourned *sine die*.

Ladies' Entertainment.

It is but fitting to add that our ladies were royally entertained throughout the convention. They appreciated this most heartily, and were loud in their praises of the Ladies' Committee, and the many Pittsburgh gentlemen who assisted in making the few days' stay in that city memorable to them.

Subscription Banquet.

Those who attended the subscription banquet at the close of the convention, and thus had the rare treat in listening to our friend Professor Brashear, as well as to noted speakers dealing with topics of the day, and particularly the Panama Canal, will have fully appreciated it. Last on the programme, but one of the best items, it is to be hoped that this feature may be extended in the future.

THE OUTERBRIDGE METHOD OF DETECTING MINERAL OIL AND RESIN OIL IN OTHER OILS.

The fine art of substitution and adulteration has not often been brought to so high a state of perfection as in the case of linseed oil. In entering a paint store to-day to purchase this vehicle for pigments, it is a question whether any is on the premises at all. Chinese bean oil will be handed over the counter at linseed oil prices. For a number of years the steamers conveying our steel products to China have returned laden with the new article of commerce, and mighty little has leaked out into our daily knowledge.

The modern core room is run on different principles than was formerly the case. Methods of handling materials have become more efficient, and a new line of binders has taken the place of the two old and reliable servants—flour and resin. These binders are dry and liquid in character, the former rather cheaper and usually containing our old friend dextrine, and the latter higher priced but more uniformly reliable when of quality, and hence preferable for important pieces of work.

The transition from the old flour and resin to the new binders has been marked by heavy expenditure on the part of the honest manufacturer of these products, as the introduction was not easy. On the other hand, it has been easy money for the unscrupulous purveyor of core binders in selling his wares as "high grade linseed oil" to those who got accustomed to using the genuine article.

As the manufacturer of good liquid binders is just as much interested in getting the highest efficiency out of the material as the foundryman, any method which will readily show up cheap adulterations which partially destroy the binding power of the oils will be highly welcome to him. Mr. Outerbridge has the thanks of the entire foundry industry for devising a simple method of detecting mineral oils and resin oils in other oils.

It may be stated here for the benefit of the supplyman that the foundryman who is shown a sample of nice thick core oil which will easily make strong radiator cores with 60 sand to 1 oil, objects strenuously when he gets his shipment so thinned down

that 40 to 1 is just safe. He thinks he can do his own thinning down if he wants to. The proof of the pudding after all is the eating of it, and if the vendor of core oils will simply disclaim any purity for his product, and sell it on a guaranteed performance as measured by standard test bars of core sand made under standard conditions, he will be miles ahead of the present practice. The sooner the makers of core oils get together on this line the better for themselves, for in this day of progress the foundrymen are apt to do it for them.

Through the courtesy of the American Society for Testing Materials, we are enabled to give extracts from Mr. Outerbridge's paper on the subject, and also the colored plate accompanying this. A sufficient number of copies of the plate was struck off at the time of printing to supply our Association. We record our hearty thanks therefor. Those who may desire to study the full text of the paper—the strictly scientific portions being omitted here—are referred to the Transactions of the Society in question.

Mr. Outerbridge says:—

Mineral and resin oils differ from all other oils in many ways, but specially in one respect. When these oils (hydrocarbon oils, improperly named "mineral" oils) whether they are crude or partially refined, are examined by reflected light, they show a peculiar greenish tinge commonly called "bloom" (fluorescence). When examined by transmitted light the bloom disappears and the true color of the oil is seen. The color ranges from dark red or mahogany tint through various shades of orange and yellow up to "water white," according to the degree of refinement. Resin oil possesses the same characteristics, except that the color of the bloom is pure blue.

The greenish bloom or fluorescence of mineral oil and the blue bloom of resin oil noticeable in daylight can be enormously intensified or magnified, perhaps a thousand fold, so that, if a single drop of mineral oil be placed in a vessel containing a hundred or even a thousand drops of pure linseed oil, or any other non-fluorescent oil, its presence may be instantly detected by the greenish fluorescence which it imparts to the whole of the oil. The same is true of resin oil which gives blue fluorescence.

By increasing the proportion of either adulterant the intensity of the fluorescence imparted to the naturally non-fluorescent oil

is correspondingly increased; and, by preparing standard samples of any non-fluorescent oil containing one-tenth, one, two, three per cent., and upwards, of mineral or resin oil, in clear glass test-tubes placed in a suitable frame against a dark background, each showing readily and unmistakably the increasing proportions of the adulterant under a light giving ultra-violet rays, a "fluorescent scale" has been established, somewhat similar to the well-known carbon color scale used in steel foundry laboratories for quickly determining, by color comparison, the proportion of carbon in an acid solution of steel.

By comparing a sample of non-fluorescent oil which has been adulterated with mineral oil or resin oil with these standards, the proportion of such adulteration may often be accurately stated in a moment by any one.

It is stated in text books on oil analyses, and also in elaborate works on oil refining, that methods of chemical treatment of mineral oil have been discovered to "de-bloom" mineral oil so that it can be used with impunity, so far as the bloom is concerned, as an adulterant for expensive vegetable and animal oils. As there is a very large trade in de-bloomed oils for this purpose, samples of de-bloomed oils of different grades and colors were obtained. These samples were free from bloom in bright sunlight or ordinary diffused daylight, or in the light from an ordinary arc lamp, but, when subjected to the kind of light to be described presently they all became highly fluorescent.

The apparatus generally used by scientists for studying fluorescence is quite elaborate and costly, consisting of quartz prisms and lenses mounted in a spectroscope and requiring highly trained observers; but, fortunately, for the practical use and value of this new method in industrial works there is ready at hand (in every establishment probably) a source of light which is peculiarly adapted to the purpose, so that no special appliances and no highly skilled operators are needed. The enclosed arc lamp is not only best adapted to and most convenient for the purpose, but actually far more effective than any of the costly outfits used for studying fluorescence. It is the ordinary enclosed arc, so commonly used in industrial works by reason of its relative economy, that happens to give out rays of the exact wave lengths needed to enormously increase the fluorescence of these oils. If the

plain glass cover of this light fits properly, so that air does not enter as rapidly as it is consumed, the arc burns in a partial vacuum or, at least, the air is rarified and, under these normal conditions, this light shows continuously, after burning a minute, a faint rosy light in addition to the powerful white light. If now a vessel containing any mineral oil, crude or refined, or any resin oil, be placed in the path of these rays the most intense fluorescence appears, even in daylight, greenish in the case of mineral oil, blue in the case of resin oil, the thin films already mentioned glowing in the same manner. So strong is this fluorescence that if one cubic centimeter of either mineral oil or resin oil be diffused in a bottle containing ninety-nine cubic centimeters of linseed oil, or any non-fluorescent oil, its presence is plainly seen.

A large number of vegetable oils, such as cotton-seed oil, corn oil, China bean oil, China wood oil, etc., have been examined and not a trace of fluorescence was found in any of them. It is stated in some text books the "oleic acid" which is found in lard oil is fluorescent. On examination it was found that pure white strained lard oil is entirely free from fluorescence under the ultra-violet ray, but all of the samples of so-called No. 1 or No. 2 lard oil (sold for use in machine shops) possessed some fluorescence, and this may prove to be a means of rapidly determining the proportion of oleic acid in lard oil.

The slight fluorescence of ordinary lard oil is different in appearance from that of mineral oil or resin oil, and does not materially interfere with the application of the fluorescent test for its adulteration with mineral or resin oil.

In order to make a practically quantitative fluorescent oil analysis in cases where the amount of mineral or resin oil in vegetable or animal oil is over ten per cent., causing too great intensity of fluorescence for accurate quantitative determinations, it is simply necessary to dilute the sample to any desired degree for the test by adding sufficient pure vegetable or animal oil, as the case may be, to bring the proportion of adulterant within that of the prepared standards. Thus, if the sample of adulterated oil showing more intense fluorescence than the ten per cent. standard is diluted with an equal quantity of pure non-fluorescent oil and then shows a degree of fluorescence corresponding with the ten per cent. standard, it is safe to conclude that it contains twenty per cent. of fluorescent adulterant.

In daily practice it is most convenient to put the standards in narrow tubular oil test bottles holding about fifty cubic centimeters each; these are corked, labeled, and placed side by side in small wooden racks (like test-tube holders) on a shelf in proximity to an enclosed arc-light, beginning with pure oil at the left-hand side, then a similar sample containing one-tenth per cent. of mineral or resin oil, as the case may be, then one per cent., and so on, increasing by single percentages up to ten per cent. It is advisable to prepare several different series of standards with fluorescent oils of different grades. Crude mineral or resin oils are much darker in color than refined oils, and the color by transmitted light is a guide to the kind of oil that has been used for adulteration and is consequently an indication of the proper standard series to be used for comparison in making a quantitative fluorescent analysis.

It is not necessary to prepare standards for each kind of vegetable or animal oil; thus, the standard series prepared with linseed oil serves for examination of cotton-seed oil, corn oil, China wood oil, China bean oil, or any other non-fluorescent vegetable oil. It is necessary, however, to prepare special standards with lard oil for testing adulterated lard oils.

The making of oil sand cores has grown enormously in recent years and many thousand dollars are spent annually by large concerns for oils for this purpose. The compounding of core oils has become a large business and nearly all the samples investigated contained mineral or resin oil or both. Neither of these oils impart any valuable properties to core oils, but are used simply to dilute more costly oils; and, in point of fact, they are positively deleterious, being of a non-drying nature, impairing the good oil binder and requiring more fuel and a longer time for baking the cores in the ovens. When we realize that linseed oil (which is the best binder) costs, at the present time, in the neighborhood of one dollar per gallon and crude mineral oil about three cents per gallon, its use as an adulterant is readily explained. Resin oil costs a good deal more and is therefore used more sparingly.

"Soya" oil expressed from beans grown in enormous quantities in China and elsewhere, is an excellent substitute for linseed oil for making cores if used in its natural state, without having been compounded or adulterated by core-oil makers. It costs

about sixty cents per gallon for fine grades. The very best substitute for linseed oil as a binder for oil cores is crude whale oil, costing about the same as Soya oil, the only objection to its use being an unpleasant fishy smell which escapes from the core ovens during the baking of cores. It makes a splendid binder. Cottonseed oil is used for the same purpose, but so much larger proportion of oil to sand is required that there is little economy in its use as compared with the other vegetable oils.

A simple and practical test of the value of core oils is to make a dozen companion test cores 1 by 1 by 15 ins. from batches of pure linseed oil and sharp sand, and also from the same proportions of any other oil and sharp sand. These are placed side by side on an iron plate and baked under precisely the same heat conditions. When cold they are broken on a transverse testing machine with supports 12 ins. apart. The relation between the average strength of the two sets of test cores is a measure of the binding qualities of the oils.

Description of Colored Plate.

This shows twenty-four samples of vegetable, mineral and animal oils by reflected light from rays of an enclosed arc lamp using 220 volts, direct current. Nos. 1 to 18, inclusive, show only orange yellow color in daylight, similar to samples numbered 1 and 7 which are not fluorescent oils.

Series A. Linseed Oil.

1	Linseed oil (pure), shows no fluorescence.			Unchanged by ultra-violet rays.
2	" " containing	0.1%	mineral oil.	Greenish-blue fluorescence.
3	" " "	1.0	" "	" " "
4	" " "	3.0	" "	" " "
5	" " "	5.0	" "	" " "
6	" " "	10.0	" "	" " "

Series B. Soya Bean Oil.

7	Soya bean oil (pure), shows no fluorescence.			Unchanged by ultra-violet rays.
8	" " " containing	0.1%	resin oil.	Pure blue fluorescence.
9	" " " "	1.0	" "	" " "
10	" " " "	3.0	" "	" " "
11	" " " "	5.0	" "	" " "
12	" " " "	10.0	" "	" " "

BY COURTESY OF THE AMERICAN SOCIETY FOR TESTING MATERIALS

Series C. Linseed Oil.

13	Linseed oil,	containing	1.0%	de-bloomed	mineral	oil.	Violet-blue	fluorescence.		
14	"	"	"	3.0	"	"	"	"	"	"
15	"	"	"	5.0	"	"	"	"	"	"
16	"	"	"	10.0	"	"	"	"	"	"
17	"	"	"	15.0	"	"	"	"	"	"
18	"	"	"	20.0	"	"	"	"	"	"

Series D. Miscellaneous Oils.

19 Cylinder oil.	Ruby-red color by transmitted light.
20 De-bloomed mineral oil.	Orange-yellow color by transmitted light.
21 Kerosene.*	Water-white color by transmitted light.
22 Gasoline.	Shows no fluorescence.
23 Resin oil.	Ruby-red color by transmitted light.
24 Ordinary No. 1 lard oil.	Pale yellow color by transmitted light.

* Owing to the comparatively faint degree of fluorescence of kerosene under the rays of the enclosed arc lamp, this light will not readily detect kerosene when present as an adulterant in small amount in any non-fluorescent oil. The more highly volatile products of petroleum, such as petroleum-ether, are not fluorescent at all. When kerosene is used even in very small quantities it is readily detected by its odor. When in considerable amount, the mixture becomes extremely limpid and suspiciously light in color. It may not be regarded as a dangerous adulterant for these reasons.

THE PROPOSED GERMAN INVESTIGATIONS ON THE STRENGTH OF CAST IRON COLUMNS.

As the consequence of a decree of the German Government limiting the allowable load on cast iron columns for buildings to 6,600 lbs. per sq. in., whereas it was formerly 9,250—and this change without being based upon a definite knowledge on the subject—the German Foundrymen's Association has appointed a commission of experts to look into the matter closely, and report its conclusions.

The commission in question, among whom we note the familiar names of Professors Martens, Heyn, and Rudeloff; Privy Councillor Juengst, and foundry engineers and managers Leyde and Mertens, promptly got to work and outlined a programme of investigations. The establishments interested in the production of cast iron columns in commercial quantities were interested, and a fund of $25,000 is now being collected to defray the necessary expenses of the elaborate investigation. In order to get a definite and satisfactory governmental settlement of the question, the tests proper are carried out at the great government testing bureau of Gros-Lichterfelde, near Berlin, and by government officials.

It may be interesting at this point to notice the differences in procedure between this country and continental Europe regarding such questions as the one discussed. Expert testimony over there is not the battle between a number of high priced shining lights retained by each party, the testimony of every one involved being either unconsciously or purposely colored to help the party paying the bills. All testimony weighed by the judges is given by experts sworn by the government, no matter whom the litigants may put on the stand, and this testimony is decisive. Hence it will be seen that in the above case the German foundrymen are proceeding very effectively, the work being done by the very men whose report will govern official action. Incidentally the government is put to no expense.

Another point of interest is that bids will be called for from foundries making cast iron columns regularly, to furnish the test pieces wanted, payment to be made from the fund raised. This

makes it an object for the foundry securing the work to turn out the proper article—also for the committee to demand it. The results will be published, but the identity of the firms doing the work kept confidential. Over here we have to depend upon the courtesy of our foundrymen in getting material to test, meaning that few pay and all reap benefits. In Germany the industry pays for what it gets, and does so willingly.

As it has been customary to make compression tests on small cylinders $\frac{3}{4}''$ to $1\frac{1}{2}''$ diameter, and of similar height, the same tests will be carried out in this work, so that the results obtained may be comparable with previous experience. Coupled with these, however, will be elaborate tests on regular columns of the dimensions given below, so that knowledge gained by testing small blocks may be coupled with full sized specimen investigations. The columns in question are to be cast at the same time that regular orders are executed in the shops, and of the regular column mixture.

The following sizes are contemplated:—Diameter of column, 4″, 6″, 8″, 10″, and 12″. Thickness of section for the respective diameters, 0.4″, 0.6″, 0.8″, 1.0″, and 1.2″. The length of the columns to be, 4″, 8″, 12″, 16″, and 20″, for the 4″ diameter and 0.4″ thick set. Similarly 6″ to 30″ length for the next set, 8″ to 40″ for the next, 10″ to 50″, and 12″ to 60″ for the last two sets. This means a series of twenty-five columns to be made from each cast.

While these columns are cast, the same metal is to be poured into cylinders 0.4″, 0.6″, 0.8″, 1.0″, 1.2″ diameter and the same dimensions respectively high.

Furthermore, as columns of the type above described should be tested not only under compression, but also for bending, so that actual conditions of service are approached, the following columns are to be cast from the same iron, and are to be tested transversely. Diameter of columns, 4″, 6″, 8″, 10″ and 12″. Corresponding thickness of section, 0.4″, 0.6″, 0.8″, 1.0″ and 1.2″, and length of each of the above five columns to be 11.12 ft. (4 metres—the usual height of a story in German buildings). All the above mentioned hollow columns to be cast flat, and the test cylinders vertical.

All castings intended for the compression tests are to have

their ends turned off and parallel to each other, the metal removed being at least half the thickness of section. The chips from the finishing cut of about 0.04″ are to be saved for analysis.

Five sets of analyses are to be made, one each from the set of columns 4″, 6″, 8″, 10″, and 12″ diameter. The five columns of each diameter with corresponding metal thickness, compression cylinders and long transverse test columns, are presumably cast from the same big ladle.

The cost of making such a test is estimated at $325, and to get a good average of the work of a foundry three sets of tests, each cast on separate days, should be provided for—making a total cost of about $1,000.

To get the average condition of the whole cast iron column industry, six foundries would have to be selected, one each from the following districts:—Westphalia, Hannover, Silesia, Hamburg, the Palatinate, and Munich.

A careful canvass of the situation has shown that there are about 125 foundries in Germany making a sufficient tonnage of cast iron columns to warrant them becoming interested in the movement, and as the first subscription of $500 from one firm heads the list, and the German Foundrymen's Association has guaranteed a further $1,250 if required, there should be every prospect of tangible results from this undertaking.

While in this country we are getting away from the cast iron column as being less adapted to the modern class of structures going up, steel being preferred, nevertheless we will be highly interested in the outcome of this work of our German brethren, as it is sure to be thorough.

BOOK NOTICES

Foundry Practice. This book, written by our fellow-member, Mr. R. H. Palmer, and published by John Wiley & Sons, of New York City, has been edited by Mr. R. T. Kent. It is a practical work, intended for the student, apprentice and molder, rather than the finished foundryman. Nevertheless, the wide-awake foundryman will do well to purchase every book that comes out on the art of founding, as the few dollars spent will always be recovered, and often with good interest, by getting some points of direct money value to the shop in question.

Mr. Palmer devotes twelve chapters to molding, beginning with the simplest classes of work and leading the student on to the most elaborate. Mixtures for sand, loam and facings are given. Cores come next, with the methods of setting them, gating, risers, etc. The treatment of castings while cooling and subsequently follows. Molding machines take up a separate chapter. Molding sands, iron, the cupola, air furnace and general foundry equipment complete the work, a chapter on brass founding being included. An appendix with miscellaneous information, and a glossary is added to the book proper.

The Heat Treatment of Tool Steel. This book, by Harry Brearley, is published by Longmans, Green & Co., of London, England, and is sold at the price of 10s. 6d. Presumably it were best ordered through an importing book house here.

Mr. Brearley gives a very complete exposition of the subject. The index indicates a very copious content. We have chapters on the classification, physical characteristics and practical working of tool steels. The changes in structure brought about by the annealing, quenching and tempering of steels. The appliances for effecting these operations properly. Case-hardening, pyrometers, etc. Also a chapter on alloy steels.

The book is well illustrated with photographs of the micro-structure of tool steels under various conditions, the curves developed by various methods of heat treatment and views of apparatus used.

A good book for those of our foundries equipped with machine shops and laboratories for investigation and standardization of processes.

The Life and Life Work of Charles Benjamin Dudley. Few men prominent in the industrial life of the nation took so much interest in the development of the foundry industry as Dr. Charles B. Dudley, of the Pennsylvania Railroad. Dr. Dudley was the foremost exponent of square and fair methods of the testing of and making specifications for materials of construction. A lovable man personally, and a patriotic citizen in representing our country abroad on many occasions.

Under the able guidance of Dr. Dudley, the American Society for Testing Materials, of which our American Foundrymen's Association is one of the earliest members, has reached its present state of prominence in the industrial economy of the nation, and the cast iron divisional work is in care of our members. The crowning glory of Dr. Dudley's career was his elevation to the presidency of the International Society for Testing Materials, at the Copenhagen Congress.

In the book in question, published under the auspices of the American Society for Testing Materials, there has been brought together not only the biography of this remarkable man, but also those presidential addresses which have formed the basis of the modern science of writing specifications. The book has been written by Dr. Dudley's friend, Prof. Edgar Marburg, the Secretary of the Association in question, and can be had by remitting $2.50 for the cloth edition, or $3.00 for the half-leather bound work, to Prof. Edgar Marburg, University of Pennsylvania, Philadelphia, Pa. The book contains 269 pages, and is a little over 6 by 9 in. in size.

Die Metall- und Eisengiesserei. By HUGO WACHENFELD. Published by Wilhelm Knapp, Halle, a. d. S., Germany. Price 5 marks, bound, in Germany.

The author will be remembered by many of our foundrymen who hospitably opened their establishments to his inspection a year or so ago. The book is an extremely concisely written compendium of the brass and iron foundry. One hundred pages of information crowd together with very little detail about all that is essential in the foundry business so far as its metallurgical side is concerned.

The book naturally describes German foundry practice only, and is well worth pursuing if one wants to get an idea of the state of the art in that country.

The only criticism that can be made is that the author is somewhat too positive in some statements, American practice pointing to somewhat different results than those obtained under German conditions.

The book is commended to those of our foundrymen who can read German, as an excellent addition to their shop library.

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